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Transporting Poles for the High Tension Line Through Cuttings Made in the Snow.

SCENES FROM SPITZBERGEN.—[See page 132.]

Torque in Aeroplane Propellers

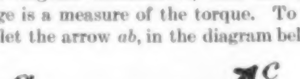
Theory and Practical Determination

Dr. A. F. Zahm

In a qualitative way much has been said and written about the influence of an aeroplane screw propeller in promoting or disturbing, by virtue of its reactionary torque, the stability of the machine it propels. As the question is one of practical importance, it seems desirable to have also a quantitative statement of this influence, first as derived from abstract theory, secondly as determined from an actual propeller by a simple experimental method.

In both theory and practice the screw propeller is found to offer three kinds of turning moment; one due to its deviation in direction, a second due to its rotatory acceleration, a third due to the air pressure on its blades. The first two kinds result from angular inertia, the third results from an external couple. They may be considered successively.

When any free rigid body sustains a torque it suffers a change of angular momentum, and the time rate of this change is a measure of the torque. To illustrate graphically, let the arrow ab, in the diagram below repre-

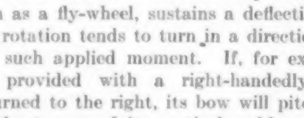


sent the actual angular momentum of the body, and bc its time rate of change. Then bc represents to scale the applied torque causing such rate of change, and ab represents the applied torque required to generate in a unit of time the actual or initial angular momentum. Furthermore, since action and reaction are equal and opposite, the resisting moment of the free rigid body is equal and opposite to the torque. It may be added that the component of bc along the line ab represents the torque component exerted in accelerating the rotatory speed, while the component of bc at right angles to ab represents the torque component exerted in changing the direction of the axis of rotation.

Such is the general theory of the torque on a rotating free body. Two particular cases are of interest here, as representing the torques of simple deviation and of simple rotatory acceleration. If, as above indicated, the body merely deviates, that is if its axis of rotation swerves in direction, while the rotatory speed is constant, the applied torque bc must be perpendicular to the axis of rotation ab. Furthermore, since bc represents the rate of change of ab, or the linear speed of the arrow point b, it must, in this special case, equal ab times the angular speed of deviation. On the other hand, if merely the speed of rotation is accelerated, while the direction is constant, bc must be in the line ab.

Restating the first case in the preceding paragraph, it may be said that when a uniformly rotating rigid body, such as a fly-wheel, sustains a deflecting torque, its axis of rotation tends to turn in a direction perpendicular to such applied moment. If, for example, an aeroplane provided with a right-handedly rotating screw is turned to the right, its bow will pitch upward owing to the torque of its vertical rudder; if turned to the left it will dip downward; and *vice versa* for a left-handed screw. Again if an aeroplane with a right-handed screw is lifted at the bow, the craft will turn to the right owing to the torque of the horizontal rudder; if depressed at the bow the aeroplane will turn to the left; and *vice versa* for a left-handed screw. These qualitative observations, so simply derived from the foregoing theory, may be prefaced as familiar to all aviators from daily experience.

To express analytically the deviating torque, let I be the moment of inertia of the rotating body, ξ its angular velocity about its axis ab, η the angular velocity of deviation, and L the torque causing the deviation. Then, as shown in diagram, the angular momentum



ab of the body equals $I\xi$, and its rate of change bc equals ab times the velocity of deviation η. Hence the deviating torque L, which equals bc, may be written

$$L = I\xi \cdot \eta \quad \text{.................} \quad (1)$$

This shows that the torque required to deflect a rigid body rotating freely, equals the product of the moment of inertia, the speed of rotation and the speed of deviation. And equal and opposite to the torque is the resisting moment of the rigid body, or the gyroscopic torque by which it resists change of its rotational direction.

But before equation (1) can be practically used it is necessary to know the value of I, the moment of inertia, or fly-wheel value. This is a physical quantity which can be computed directly for the given body, if it be a homogeneous geometrical solid; but for engineering bodies, because of their ungeometrical form, the value of I has quite usually to be determined instrumentally. This determination is commonly made by means of a torsion pendulum. The body is suspended from a vertical wire and set vibrating torsionally about the wire. It is then replaced by an exact geometrical solid whose moment of inertia is precisely calculable. The moment of inertia of the body is then found by comparison with that of the geometrical standard, the two moments of inertia being to each other as the squares of the observed periods of vibration.

A simpler method of finding the moment of inertia of any irregular solid about any chosen axis is to set the solid vibrating as a gravity pendulum about that axis, and observe the period of oscillation. If then its mass and centroid are known, the moment of inertia can be computed by a special formula which is convenient for all ungeometrical figures, and especially for those symmetrical ones such as fly-wheels, propellers, etc., whose centroid is known. The formula seems worth deriving here.

To do this let q be the radius of inertia measured from the test axis about which the irregular body vibrates, say on knife edges; let l be the length of the equivalent simple pendulum; and let r be the distance of the centroid from the same axis. Then the following simple relation obtains, as proved in elementary mechanics:

$$q^2 = rl.$$

The value of l is computed from the observed vibrational period t, by means of the well known formula

$$l = gt^2/\pi^2$$

and then on substitution gives the value of q in terms of r and t, which are easily measured. Thus the radius q, and hence the moment of inertia for the chosen axis of swing, is simply determined.

From the foregoing may at once be computed the moment of inertia referred to the parallel centroidal axis, which for fly-wheels, propellers and the like should be the axis of symmetry about which the body runs. Calling q_0 the radius of inertia referred to this axis, it is directly found from q and r by means of the well known relation

$$q_0^2 = q^2 + r^2$$

since r is the distance between the actual axis of vibration and the gravity axis. Hence finally the moment of inertia I, referred to the gravity axis is found to be

$$I = Mq_0^2 = M\left(\frac{rgt^2}{\pi^2} - r^2\right) \quad \text{..........} \quad (2)$$

in which M is the mass of the vibrating body.

Suppose, for example, that it is required to find the moment of inertia, referred to its running axis, of a wheel of known mass and diameter. The wheel is supported on knife edges at its rim and its time of swing is noted. The required quantity I, is then found by substituting in the above formula (2) the values of the mass, radius and time of one swing, or of half a complete vibration.

In this way the writer has determined the gyroscopic influence of a wooden screw-propeller made by Mr. Glenn H. Curtiss for the first hydro-aeroplane built for the United States Navy. The screw-propeller measures 8 feet in diameter by 4.5 feet pitch, weighs 17 pounds, and runs at 1,200 revolutions per minute, or 40π radians per second. When suspended by its tip it performs 24 complete vibrations, or 48 swings, per minute. Hence t is 5/4 of a second, which substituted in equation (2) gives

$$I = 17\left(\frac{4g \cdot 5^2}{4^2 \cdot \pi^2} - 4^2\right) = 74.5.$$

From this the gyroscopic torque due to any velocity of deviation η, may by (1) be written

$$L = 74.5 \times 40\pi \times \eta = 9366\eta \quad \text{poundal-feet,}$$
$$= 291\eta \quad \text{pound-feet.}$$

If, for example, the aeroplane deviates from its course, in regular full speed flight, so much as half a radian per second, which means a turn through 180 degrees in six seconds, roughly speaking, the gyroscopic torque is 145 pound-feet, tending to make the aeroplane pitch or dip. A fairly sharp turn would be one-third as fast as this, begetting a torque of about 50 pound-feet, which is equivalent to 5 pounds acting on a rudder ten feet long. Apparently this is not a very considerable quantity; but it may be much increased by the addition of a rotatory engine to the gyrating mass of the propeller.

Mr. Sidney V. James, who has very kindly read the manuscript of this article, and applied the vibrational method to a fifty-horse Gnome motor, reports that its moment of inertia is 52.6, in absolute units. Hence the gyroscopic effect of such a motor combined with a Curtiss 8-foot propeller is 1.7 times the value found for the propeller alone. As the propeller weighs but 17 pounds, while the rotating parts of the engine in question weigh 123.7 pounds, or nearly eight times as much, certain "practical" inventors and mechanics have thought the gyroscopic effect of the propeller far less than that of the engine, whereas in the present case it proves to be 10/7 times as great. Those gentlemen, therefore, who are trying to sell stock on an engine having no angular inertia, yet employed to drive a single screw, would do well to look to the angular inertia of their propeller.

The torque due to simple rotatory acceleration is given by the formula well known in elementary mechanics,

$$L = I\alpha \quad \text{..................} \quad (3)$$

in which α is the angular acceleration about the axis of rotation. For example, if the given propeller of the naval hydroaeroplane attains in one second its full speed of rotation of 40π radians per second, the angular acceleration α is 40π, and the consequent torque is, by equation (3)

$$L = 74.5 \times 40\pi = 9366 \quad \text{poundals-feet,}$$
$$= 291 \quad \text{pound-feet,}$$

or the equivalent of 29 pounds acting on an aileron of 10-foot leverage. This is equivalent also to a mean total piston pressure of 873 pounds on the 4-inch crank of the engine. The actual acceleration indeed rather exceeds this amount; for the mean total crank pressure must be a little over nine hundred pounds in order to develop 70 horse-power at 1,200 revolutions per minute, as required of the Curtiss 8-inch engine built for the United States Navy.

After the brief instant of acceleration, the propeller torque due to the impact of the air on the blades takes up the full available moment of the engine. This torque may be measured very easily and used to compute the power of the engine, since the power of a motor equals the product of its torque multiplied by its angular velocity. If, for example, the engine is mounted on a rectangular frame supported by four parallel ropes attached to the corners, as sometimes practiced in measuring the propeller thrust, the torque may be computed as the product of the distance between the pairs of ropes on opposite sides of the engine multiplied by the change of tension in either pair due to the torque. The change in tension may of course be revealed by a dynamometer, by movable weights, or by other obvious means.

This principle is employed by Mr. Curtiss in a slightly different way. He mounts the engine on a wheeled truck, for convenience in moving, and runs this truck on rails on a horizontal table leaf having one edge hinged to the side of the laboratory, and its other edge resting on a platform scale. The propeller thrust therefore pulls the truck along the rails parallel to the side of the house, stretching the dynamometer, and the torque causes an increased reading on the platform scales, by which therefore the propeller moment is easily determined. This torque multiplied by the angular velocity of the motor gives the power of the engine, as by the preceding method.

The quadrifilar suspension is a good arrangement for determining simultaneously the propeller thrust and torque. But some caution is needed in finding the true torque, if the center of gravity be relatively high above the points at which the ropes are attached to the frame supporting the motor. To show this, suppose d to be the distance between the ropes on opposite sides of the engine, and h the height of the center of gravity of the engine and supporting frame above the horizontal plane of attachment of the ropes. Suppose also that the torque causes this plane to cant through a small angle ϑ, owing to the extension of the dynamometer used to show the change of tension in the supporting ropes on one side of the engine after the torque is applied. Then the center of gravity will shift laterally a distance $h \sin \vartheta$, and introduce the moment $Wh \sin \vartheta$ conspiring with the torque of the motor, w being the total weight suspended. This item should therefore be taken into account, unless the apparatus be so arranged and proportioned as to make $Wh \sin \vartheta$ a negligible quantity. Obviously also the apparatus can be so designed that the displacement of the center of gravity will measure both the torque and thrust of the propeller, and even indicate the horse-power. But the details of this arrangement may be left to the ingenuity of the experimentalist. In passing it may be said that the above estimated correction, $Wh \sin \vartheta$ applies likewise to Mr. Curtiss' apparatus and to the Brackett cradle in its general theory.

The Purity of Natural Waters—I*

The Influence of Aquatic Organisms, of Domestic Sewage and of Industrial Waste

By Maximilian Marsson

In 1867 the Danish naturalist, Peter Erasmus Müller, while on a visit to Switzerland, first noticed that the waters of the Swiss lakes were teeming with small crustacea. Previously it had been considered that these clear waters contained no living organisms, and the confirmation of Müller's observations by the examination of bodies of water in other parts of Europe caused much astonishment. These investigations revealed not only minute crustacea, but also enormous numbers of rotifera and protozoa, thus showing that these animalcules were cosmopolitan in their distribution. The detailed study of these organisms in Lake Leman was first undertaken about 1870 by the Swiss naturalist, F. A. Forel, and soon after 1880 other Swiss lakes were examined by Asper, Heuscher and Imhoff. They found that the microscopic organisms spent their lives swimming in the water, and that many low forms of plant-life were associated with these small animals. This is true of the ocean as well as of bodies of fresh water. The marine investigations were undertaken by Dr. V. Henson, of Kiel, in order to study the transformation of matter in sea water, and in 1887 he published his important work on "The Determination of the Plankton, or the Animal and Vegetable Matter drifting about in the Sea." The appearance of this book marks a new epoch in hydrobiology, and particularly in respect to quantitative investigation.

THE PLANKTON.

By the term "plankton" Henson meant "everything that drifts about in water," but it is preferable to define the word as embracing "all living matter that drifts involuntarily," as drifting dead matter is now called "pseudo-plankton." The plankton thus includes all living organisms drifting about or remaining suspended in the water between the surface and bottom, but without ever coming in contact with the latter; and its distribution depends mainly on winds and currents, being affected only in slight degree by the locomotive powers of the organisms themselves. In addition to suitable adaptations for nourishment, propagation and protection against foes, as usually found in the animal world, this large living community also requires the further peculiarity of organization which enables the individuals to remain suspended in the water without appreciable effort on their part. The quantitative investigation of freshwater plankton was advanced greatly by C. Apstein, a pupil of Hensen, who published in 1896 a comprehensive treatise on the subject.

The study of fresh-water and marine plankton is now carried on at biological stations in many places on the earth's surface. Austria has such a station which was established in 1888 by Prof. Fritsch of Prague at the Unternitzer Pond, and Germany has one that was established in 1891 by Prof. Otto Zacharias at Great Plöner Lake. For practical pisciculture, biological experiment stations have been located at Muggel Lake and Trachenberg. The advantage of such stations consists in the possibility of studying systematically all conditions of aquatic life in every season, kind of weather and mode of illumination, and also of utilizing to the fullest extent many more observations afforded by constant proximity to the water than could be gained by occasional visits.

In the following pages it is my purpose to consider in somewhat greater detail the various groups of hydrophytes and hydrozoa, and especially their relation to the self-purification of water. The other factors of self-purification, such as the chemical and physical or mechanical agencies, will not be considered here. I have called attention particularly to the plankton, because its vegetable component is the fundamental food supply or condition of existence for all aquatic life. It comes from the products of the decomposition of the albumen which finds its way into the water from decaying animals and plants as well as from sewage. The self-purifying power of natural waters is merely the maintenance of the proper equilibrium between retrogressive and progressive metamorphosis, and frequent reference thereto will be made in the following.

In discriminating between vegetable and animal plankton, also taking into account the remaining aquatic organisms that are found on the bottom and shores, we find that we must divide them into two classes, viz. Food Producers and Food Consumers. The plants which assimilate inorganic matter and build up organic compounds by means of their chromophyll coloring matter, belong to the first class; and all other organisms, such as microscopic protozoa, rotifera, etc., together with the larger ones up to the fishes, belong to the second class, or food consumers.

VEGETABLE PLANKTON: FOOD PRODUCERS.

Let us now consider the Plants somewhat more closely. In the waters algæ play the most important part, as they exhibit the greatest diversity of form. They are found in all places where water has collected, even in the long-stagnant rain water, but their vegetation varies with the seasons and the character of the water. While the plankton contains many unicellular forms and coherent colonies, or strings of such, we find in shallow waters, streams, ditches, and shores mostly the confervæ, or threadlike algæ which appear as thick mats or strands of light or dark green color. The blue-green group called schizophyceæ is also widely distributed, and representatives thereof usually produce the so-called "blooming" of our rivers and lakes, while others, especially the oscillatoria, often settle in strongly polluted water courses, such as the gutters and ditches of unsewered towns and the drainage channels of barnyards. When they form a covering of wet and polluted ground, they usually have a deep black color, but similar kinds are sometimes red, and have been mistaken for dried pools of blood.

The other groups of algæ have only a few representatives in fresh water. Of these the diatoms and bacillariaceæ have been most extensively studied by microscopists, as they are found in all seasons in every water course and pool from the pole to the equator, and as well in icy streams from glaciers as in hot springs. They sometimes appear in such enormous quantities as to render a counting of individuals impracticable. It was formerly believed that in winter our frozen rivers and lakes were devoid of life, as the water was then unusually clear; but on closer examination by filtering the water through a net of fine silk gauze, or by killing the living organisms with alcohol, formalin, etc., and concentrating them by sedimentation or other means, an abundance of microscopic organisms of various kinds, and especially diatoms, will be found in all seasons. The cell body of these algæ is held together by a silicious skeleton, which has often so delicate a structure as to be defined clearly only by the best microscopes; and hence certain species of diatoms, such as Surirella Gemma and Pleurosigma Angulatum, are used as test objects for the best objectives. Through their brown coloring matter, called diatomin these silicious algæ are as capable of assimilating organic matter as are the green and blue-green algæ by means of their normal green coloring matter called chlorophyll.

As the assimilative activity of the algæ is a very important factor in maintaining the purity of our streams, it is necessary for us to consider briefly the structure of the microscopic plant cells, of which the higher plants are composed.

In opposition to the animal cell, a well-defined vegetable cell is inclosed by a dense skin, called the membrane. For this reason the cells of a plant are sharply separated from one another. Each such cell possesses a much greater independence than the cells of the body of an animal, or at least of the higher developed animals. In almost every plant cell there is a nucleus, the remainder of the volume being filled by the cell plasm or cytoplasm, which is rich in albuminous substances, and in which the carriers of coloring matter, or the chromatophores, are distributed. These three components (nucleus, cytoplasm and chromatophores) taken together are commonly called protoplasm, or more briefly plasm, which includes all the living constituents or protoplasts of the cell. The chief function of the cell is based upon a reciprocal action between the nucleus and the plasm. The chromatophores or chloroplasts, however, whose predominant green coloring matter is chlorophyll, exercise an important function in the cell, since with the help of the vibrations of light they are enabled to dissociate carbon from the carbonic acid that is contained in air and water, and to prepare with the elements of water organic matter having little oxygen. Polymeric carbonaceous products are thus formed which then develop into starch and certain kinds of sugar; and these compounds, in conjunction with the simplest combination of nitrogen, finally serve to form albumen and other complex combinations for the use of plants, whereby the weight of dry organic matter in the latter is increased. The nitrogen required to form the albuminous compounds is obtained from ammonia and nitrates, and other elements found in the ground and water also appear to play a not less important part in the formation of albumen.

Assimilation.—This entire synthetic process, in which oxygen is dissociated from carbonic acid in the form of gas, is called Assimilation. It is the same in land plants as in aquatic plants. In the case of the latter, the highly developed as well as the microscopically small, the necessary supply of carbonic acid is derived only from the surrounding water. In the diatoms the starch is replaced by a fatty oil, which develops more abundantly in the species that grow upon the bottom than in the seamless species which live freely suspended in the water, and usually constitute the greater part of the plankton of sluggish streams. After the winter's cold has passed away and the heat rays of the sun are able to penetrate deeply into the water, however, the microscopic plants which have been dormant on the bottom are stimulated to renewed activity and multiply with amazing rapidity, whereupon they are lifted upward by the assimilation gases and appear on the surface of the water. In March, April and May, thick brown masses are seen floating in our rivers, and are commonly regarded as filthy or disgusting matter; but on examining a small portion thereof under a microscope, it will be found to consist of amorphous earthy and dead organic matter intermixed with bubbles of gas and swaying tangles of blue-green filaments called Oscillatoria, among which countless diatoms may be seen gliding to and fro. Both of these varieties of algæ possess a remarkable power of motion, which render it possible for them to crawl about on the bottom or to move in the sludge on the bed.

The seamless diatoms of the plankton do not require this ability to move about, as they are held in suspension by their peculiar shape; but the species that live on the bottom have a seam at which pulsations of plasm that produce motion are manifested. It is very interesting to observe how a parallelism has developed between the biological relations and the morphological structure of an organism. The algæ which are lifted from the bottom by gas bubbles and are not normal constituents of the plankton, are scattered about in running water and purify it by removing therefrom the carbonic acid which has accumulated during the winter. This is done by dissociating the oxygen from the acid and letting the former aerate the water. Such indirectly anti-putrefactive organisms generally develop in places where they are most needed, as in localities where the bottom consists of organic sludge or detritus of every kind instead of clean sand.

The production of oxygen, however, is not limited to the activity of the minute plants mentioned, but is maintained by all the other plants which are found in the streams throughout the entire year, even under the ice in winter, although in reduced numbers. As is to be expected, the assimilation gases act very energetically, especially in their nascent state, in oxidizing dissolved organic matter, and atmospheric oxygen is by no means so efficient. The plant life of a stream is therefore of the utmost importance, while the sun must be regarded as the source of the energy required for the development and growth of all these organisms.[1]

To be continued.

Anti-typhoid Vaccination.—Very favorable reports are made with regard to the successes of anti-typhoid vaccination; especially the experiments of Prof. Vincent, in Morocco, are worthy of notice. The vaccine can be prepared in two ways. According to one method, says *Cosmos*, an extract of dead typhoid bacilli is prepared with ether; the product obtained is known as "autolysate." Another preparation consists of an emulsion in salt water of microbes killed with ether. The appended table of the results obtained by the use of this vaccine speaks for itself:

		Typhoid Fever.	Febrile gastric affections.	Total.	Deaths.
Non-vaccinated	Per thousand	64.87	50.90	115.77	8.35
Vaccinated.....		0	0	0	0

*This fascinating epitome, reproduced from the *Engineering News*, of the important rôle played by the aquatic flora and fauna in maintaining the purity of streams and lakes was written by the late Dr. Maximilian Marsson, as the latest revision of a lecture which he had frequently delivered before the Royal Testing Station for Water Supply and Sewage Disposal at Berlin, Germany, with which station Dr. Marsson was connected at the time of his death. The lecture, as here translated by Emil Kuichling, originally appeared in "*Mitteilungen aus der Koniglichen Prüfungsanstalt für Wasserversorgung und Abwasserbeseitigung*," 1911, having been prepared for publication by Dr. Marsson's associate, Prof. R. Kolkwitz.

[1]Prof. R. Kolkwitz remarks on the action of oxygen: The question of the presence of atomistic oxygen in plant cells requires more thorough investigation, as it has not been found outside of the plasm. Compare W. Pfeifer, "Contributions to the Knowledge of the Processes of Oxidation in Living Cells," in Abhandl. der Math. —phys. Klasse d. Kgl. Sachs. Ges. d. Wiss., 1889, vol. 15, p. 430. Marsson maintained that living specimens of Riccia Fluitans were capable of forming active oxygen.

Fording a River With Poles for the High-tension Line.

The Picturesque Camp of the High-tension Line Gang.

Spitzbergen, Its Past and Future

Winter Sports for the Modern Summer Tourist

By Dr. Alfred Gradenwitz

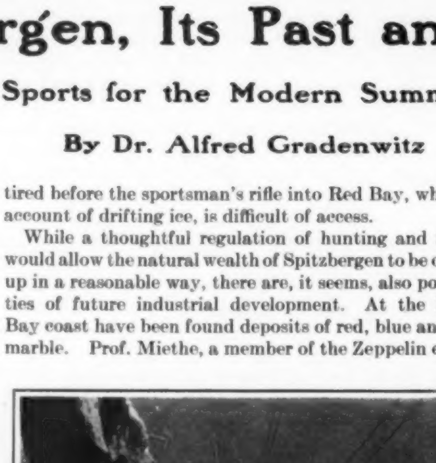
Spitzbergen, a large group of islands in the Arctic Sea, has been receiving increasing attention of late years, both on account of its economical and scientific possibilities and as the goal of amateur explorers. With its typically arctic climate and grandiose mountain scenery, this country, within easy reach of continental Europe, holds out to the ordinary mortal a promise of all the sensations of North Pole travel. The temperature, even in summer—during the four months of uninterrupted daylight—remains low enough in the shade to prevent the ice and snow from melting, while in the sun there may be considerable warmth, allowing a comparatively luxuriant flora to develop. The fauna is likewise rather variegated, comprising all kinds of arctic fur and marine animals (whale, walrus, etc.), reindeer and, in summer, plenty of sea-birds.

Spitzbergen was not always the barren uninhabited country it is now. Discovered in 1596 by the Dutch, who supposed it to be part of Greenland, it soon became a center of active whale and walrus fishing. In fact, this industry made the wealth of Holland long before the Japanese sugar-cane filled the purses of her merchants. The whaling colony of Smeerenberg, situated between King Jacob's Land and Amsterdam and Danes' Islands, reached the acme of prosperity in the seventeenth century when it formed quite a little town, though only a summer community. Here, with the growing affluence of inhabitants, licentiousness developed in all its various forms, much as is usual in newly discovered gold fields. While there is nobody left to tell the tale of his ancestors' deeds, the stones so numerous on Spitzbergen are eloquent enough: A heap of stones is found on the Isle of Amsterdam, the inscription on which bears witness that here is the burial place of many whale hunters. Not far away, near Magdalen Bay, in front of Gully Glacier, the bones of many Englishmen who waged war with the Dutch for supremacy in whale fishing are seen bleaching in the sun. Only some earthen walls of sperm oil ovens are now left of all the former splendor of Smeerenberg.

Not far away, in Virgo Harbor, there are, however, some records of more recent date and at the same time promises of future development. After the decline of whale fishing, when Smeerenberg had been abandoned, there was a long break in the history of Spitzbergen, until modern arctic travel again drew the attention of the world to that group of islands. In 1907 Andree, the hapless Swedish engineer, with two companions, rose in a spherical balloon from Virgo Harbor to discover the North Pole. A simple monument, heaped up from rough stone blocks in front of the balloon yards, bears a commemorative inscription, telling of the daring explorer's sad fate. Much more pretentious are the remnants of Wellman's installations, who some years afterward, started in a dirigible balloon to seek the North Pole and who has since attracted public attention by his attempt to cross the Atlantic in a balloon, an attempt which is to be repeated by Wellman's engineer, Mr. M. Vaniman.

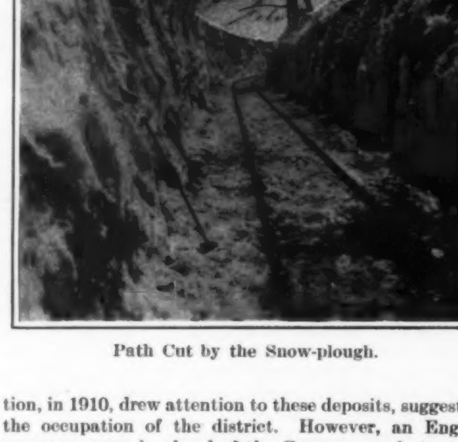
At the Green Harbor whaling station, erected within recent times, about 200 to 300 whales are annually disposed of. On account of the ruthless hunting of former ages and the absence of any regulation (Spitzbergen being under the rule of no country), the day seems near at hand when the last whale in these tracts will have been killed. The polar bear has likewise withdrawn into the interior, and of the decimated reindeer only antlers are still found in abundance, while the animal itself has retired before the sportsman's rifle into Red Bay, which on account of drifting ice, is difficult of access.

While a thoughtful regulation of hunting and fishing would allow the natural wealth of Spitzbergen to be opened up in a reasonable way, there are, it seems, also possibilities of future industrial development. At the King's Bay coast have been found deposits of red, blue and gray marble. Prof. Miethe, a member of the Zeppelin expedition, in 1910, drew attention to these deposits, suggesting the occupation of the district. However, an English company came in ahead of the Germans, and started a quarry, on a modest scale. A small wooden cabin was erected accommodating a dozen men and blasting has quite recently been begun. Moreover, on the opposite side of the bay, in front of Zeppelin Harbor, coal was found two years ago. An English company has started operations on this deposit, though, so far without any marked success.



Path Cut by the Snow-plough.

While trips to the southern coast of Spitzbergen have for some years past formed part of the regular program of some shipping companies, the North German Lloyd last year for the first time took a conducted party as far north as northwestern Spitzbergen. The country will doubtless in the near future become a center of tourist travel and sporting. Wellman was able to build a comfortable house where he spent a most pleasant summer, and there seems to be no reason why a large hotel or at least some block houses should not be erected, where tourists could spend a few weeks to restore their health or to indulge in the midst of summer in all forms of winter sport. In this country of ice and snow, where microbes are reduced to a minimum, victuals could be kept for weeks without any special storage cellars. The magnificent alpine scenery and arctic surroundings would appeal to the lover of nature and while there would be a ship calling from the European continent every ten or fourteen days, wireless telegraphy would keep the traveler at all times in direct communication with his home country.



Shelters for Line Guards Cut in the Snow.

Norway has in fact recently erected on the east coast of Green Harbor a wireless station communicating with a sister station on Ingö, an island near Hammerfest (the northernmost city in the world), thus for the first time establishing permanent connection between the arctic and the outside world. As the electro-magnetic waves have to traverse huge mountain ranges between Green Harbor and the south cape of the island, the position of the wireless station cannot be said to be very fortunate. The energy of the signals is accordingly made relatively high. On account of the difficult conditions of operation, the Spitzbergen plant was equipped with a duplicate generating set, so that the central station comprises two oil motors of 30 horse-power each, two 16 kilowatt dynamos, 2 accumulator batteries each of 60 cells and 2 10-kilowatt converter sets.

The cooling water of the motors is pumped up into large iron reservoirs heated uniformly. Two huge anthracite stoves provide efficient heating, the temperature on Spitzbergen being exposed to severe fluctuations, frequently dropping as far down as −45 deg. Cent. Two iron frame work poles were erected for carrying the aerial wires and these constructions as well as the remaining installations involved some difficult construction. No less than 350 barrels of cement and upward of 5,650 cubic feet of sand had to be conveyed in a special vessel from Norway, to be used for the understructure of the towers and wire system. About forty men were engaged in building the station, which comprises a dwelling house, a power house, two store houses for 150 barrels of kerosene, coal and wood sheds, barracks and several smaller houses. The personnel of the station comprises a manager, two telegraphists, an engineer and a cook. This wireless station has communicated with the huge stations of Poldhu (England) and Norddeich (Germany).

Apart from this economical development, Spitzbergen has also been the subject of scientific exploration, especially at the hands of Swedish and Norwegian savants. If German science has recently begun to pay attention to this arctic country, this is due to recent developments in meteorology, which has transferred the center of interest to the higher strata of the atmosphere. Several scientific expeditions have been undertaken to study the behavior of the atmosphere over the ocean and at certain characteristic points of the surface. Prof. Hergesell of Strassbourg University, who since 1904 was almost a constant guest on the yacht of the Prince of Monaco, whom he accompanied on all his scientific expeditions

realized the importance of a scientific station at Spitzbergen for meteorologic study. While captive balloons and kites had allowed the polar atmosphere to be investigated in the summer, no attempt had in fact been made to continue these investigations during the winter. Thanks to the assistance of the German Emperor, the Zeppelin Arctic Expedition and Count Zeppelin himself, who is of course interested in ascertaining the meteorological condition of the arctic regions for his contemplated arctic balloon journey, this station has recently been installed on the Advent Bay, close to the coal mines which are worked throughout the winter. The personnel of the mines will assist in operating the station. The latter is fitted up with different kinds of aerial craft, for investigating the upper atmosphere, comprising kites and captive balloons actuated by a special electric winch and pilot, as well as recording balloons. A small motor launch plying on the ice fjord will be used to recover balloons that may drop into the water. In order to make the best of the possibilities of this station, the scientific work is to be extended to geo-physical investigation on a large scale. It is therefore equipped with seismometric apparatus for recording earthquakes and with instruments for studying atmospheric radiation and electricity. A wooden building of the Arctic Coal Company has been placed at the disposal of this station, as dwelling house for Drs. Rempp and Wagner. Special sheds were erected for housing the magnetic and seismic instruments, and three meteorological observatories have been installed at different heights for climatological investigation, all of which are equipped with self-recording apparatus.

The writer wishes to express his indebtedness to the Editor of *Nordland*, the Directors of the North German Lloyd and to Prof. Hergesell for courtesies extended to him in preparing this article.

An Automatic Thunder Storm Recorder

The Electric Wave Detector in Service of Meteorology

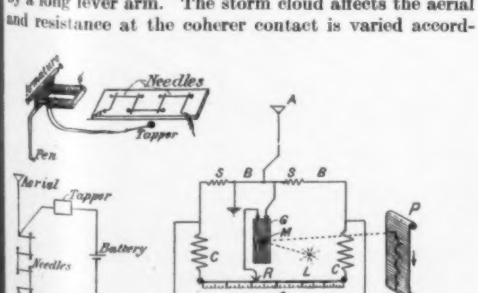
By the Paris Correspondent of the Scientific American Supplement

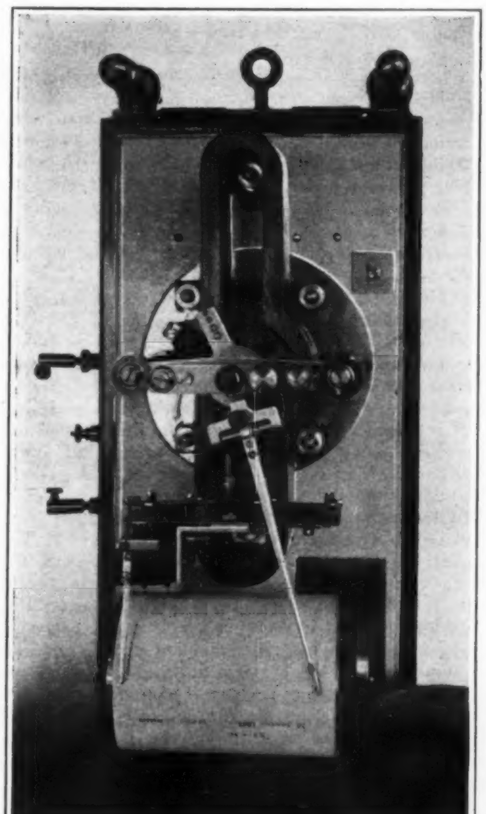
APPROACHING thunder storms can be indicated as much as four hours before they arrive, by the new instruments which Prof. Turpain has devised. Prof. Turpain uses the action of the coherer in order to detect the presence of electric discharges in the atmosphere, or in other instruments, he uses an electrolytic detector of the kind commonly employed in wireless telegraphy. Not long since he installed a storm-indicating station in the western part of France at La Rochelle, in the highest part of the town. He uses an 80-foot factory smoke stack to carry the top end of an aerial wire, and from here the wire runs to an adjoining roof and then to the ground. The whole length of the aerial is about 300 feet and the lower end runs into the laboratory where the different instruments are set up.

We illustrate a number of electrical thunder storm indicators used by Prof. Turpain. We are indebted for these to the makers, the Richard establishment of Paris. He finds that the best kind of coherer to use for registering the atmospheric discharges is made by placing a number of heavy sewing needles crosswise, making a number of contacts between them. Such contacts are not sufficient to allow current to pass through them except when the electric discharge comes on, and then the contact is made on the usual coherer principle so that the current now passes through the set of needles and affects an electrical instrument. Small weights are put on the upper needles so as to give a better pressure, and a battery of one single cell is used. One of our views shows the simplest kind of thunder storm indicator, combined with a Richard aneroid barograph. The lower needle is worked by the barometer and registers by its pen upon the revolving drum in the usual way. Above is mounted Prof. Turpain's device, and the set of needles forming the coherer are placed on a light board. Underneath is a tapper worked by an electromagnet so as to strike against the board and restore the coherer at the end of each discharge. On the tapper is also a light arm which works by the same action and thus registers on the drum at a point lying above the barometer mark so that the chart always shows the state of the barometer along with the storm signals. When a thunder storm acts on the aerial, the effect on the coherer is enough in most cases to operate the instrument and register the electric discharge. Then the tapper restores the coherer and a new discharge is registered, and so on. The effect of the storm cloud is strongest when the discharges lie close together.

A step farther in this direction is to be able to gage the distance of approaching thunder storms. This is done by using an instrument somewhat different from the above in order to record the actual values of the electrical effect. In this way it is possible to observe whether the effect given by a storm cloud keeps on increasing, indicating that the storm is on the way.

One of our engravings represents an instrument of this kind. The coherer board and tapper remain about the same, but the current going from the coherer passes through a sensitive galvanometer which measures this very weak current and records it upon a large drum by a long lever arm. The storm cloud affects the aerial and resistance at the coherer contact is varied according to the strength of the electric discharge, so that at first we have a varying current and the recording lever follows this up to the point where the current is strong enough to work the tapper. Then the coherer is restored and the action begins again. Should the action of the cloud remain small throughout, the record will be continuous, since in such case the tapper does not work. It seems, however, to protect the sensitive instrument from an over-discharge which would be likely to damage it. While the first form of apparatus only shows the moment of the discharge, the second form gives us some indications of the movements of the storm.



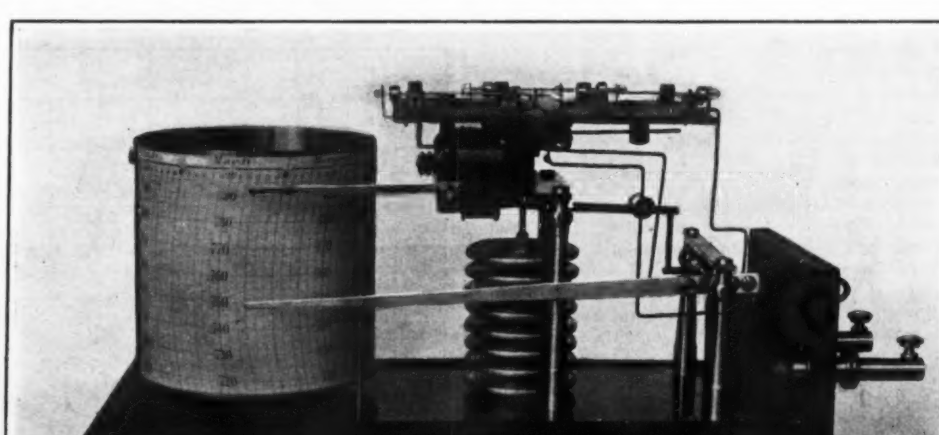


Thunderstorm-recorder. View Showing Needle-coherer, Galvanometer and Tracing Drum.

As the galvanometer instrument is very sensitive it must be well protected from shocks or vibrations of the building. Prof. Turpain suspends it from a fixed support by stout rubber bands, using a slack steel cable or chain to give safety in case the rubber should break. The tapping device also carries a recording arm as in the first apparatus, and acts in a like manner to record the number of discharges.

The strength of the electric discharges is best given, however, by a third form of apparatus. While this gives more valuable indications it is also a more difficult one to use as it works on the principle of recording the discharges, or the current corresponding to them, by a bolometer, and the record is made on a moving photographic band. The bolometer device comprises a pair of very fine stretched platinum wires mounted so that they can be kept within a double-walled silvered glass vessel such as is used for holding liquid air, and this acts as a guard against external temperature effects. The platinum wires are connected in the aerial circuit and are balanced against German silver resistances on the Wheatstone bridge principle, so that when a discharge occurs the resulting current acts on a sensitive reflecting galvanometer. A beam of light is reflected from the mirror of this galvanometer onto a moving band of photographic film or paper, so that a continuous record is obtained. The amount of movement of the light beam corresponds very closely with the amount of energy of the storm discharge, so that Prof. Turpain considers this to be the most accurate method of observing approaching storms and finding their value, although it needs more care and skill to handle. The experiments made at the La Rochelle station are very promising.

A New Cleaning Fluid.—This liquid consists of the following ingredients: Concentrated ammonia water, 31 parts; tincture of soft soap, 93 parts; soda, 7.8 parts; borax, 7.8 parts; ether, 31 parts; alcohol, 31 parts, and water, 798.4 parts. The salts are first dissolved in part of the water, then the other ingredients are added, finishing with alcohol and ether. This fluid is said to remove any kind of spots from woolen fabric, imparts luster to black cloth, and is well suited for cleaning carpets. It must be kept in a well stoppered bottle. Remember that ether is excessively inflammable. The mixture should be prepared by day and no flame should be allowed in the same room as the open bottle of ether.



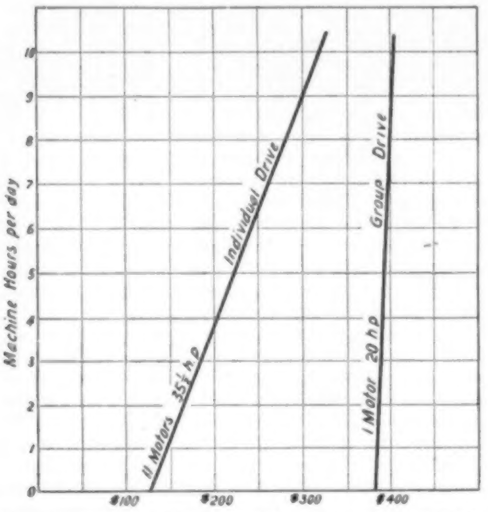
Turpain's Recorder with Aneroid Barometer Attachment. Both Records are Made on One Drum.

The Cost of Industrial Electric Power*

The Relative Advantages of Group and Individual Motor Drive

By C. W. Drake

Motor drive is not as some people are inclined to believe, a panacea for all industrial ailments, although there are but few plants in which motor drive, properly applied, will not improve conditions. Hence, it may ordinarily be assumed that motors are to be installed, and the questions to be settled are: What type of drive to use, and whether to generate the power or to purchase it from a central station. It is not the purpose of this article to attempt to show how to lay out an electrical equipment for any special industry, but rather to call attention to some of the more important factors bearing on the type of drive to be used, and the power supply.



Annual Cost = Fixed Charges + Friction Losses at 4c. per Kw.hr

Fig. 1.—Relative Annual Cost.

Motor drives are installed because they produce a greater profit in the industry, and not because they are the ruling fad. Increased profit may result from increased quantity, improved quality, reduced power consumption or a combination of these conditions. Consequently, before any action towards the installation of motors is taken, figures should be available showing what may be expected in the line of first cost, power consumption, maintenance, and improved manufacturing conditions from several systems of drives.

There are two general systems of drive; namely, group and individual, and the choice between these two for various applications is often a question of dispute. The power cost in most industries is less than 5 per cent of the total manufacturing costs, so that a slight increase in production will quickly offset a large saving in power and consequently the item of prime importance in laying out motor drives is production, and after all items bearing on it are taken care of, the question of power cost and type of drive may be considered. Each installation is a separate problem in which there are many factors and the degree in which one or more of these various factors predominate, determine the type of drive to be used.

Outside of factors bearing directly on production, other points to consider when comparing group and individual drive are:

1. Investment.
2. Rate for power.
3. Machine load and time factor.
4. Shafting friction.
5. Maintenance.

Investment is one of the principal factors that prevent the installation of individual drives, since this figure can be quite accurately determined while the saving in energy is more or less approximate and problematical.

With individual motor drive the total horse-power rating of the motors installed in a plant will be considerably greater than with group drive, but the maximum power demand of the plant is approximately the same in either case. Some power contracts with central stations are based on the horse-power connected, or on the maximum demand considered as a certain percentage of the connected load. It is easily seen that a rate basis as above would tend to prevent the installation of individual drives since a group drive would obtain a lower basic rate, although the high efficiency of the individual drive would tend to reduce the actual power consumed. A more logical basis of charging for power would be on the actual maximum power demand which is either estimated or obtained by test, together with the actual energy consumed. On this basis the individual drive by reason of its lower transmission losses will show a lower power cost than the group drive.

In group drive there are two distinct loads, the variable load of the machines and the friction of the shafting and belting. The lower the machine load factor, the greater becomes the percentage of the friction load and the more inefficient the transmission.

In order to show more clearly the relative advantages of individual and group drives, an example has been made of an existing planing mill. At present a 20 horse-power 840 revolutions-per-minute squirrel cage induction motor is installed, driving eleven machines by means of a 60-foot shaft (eight hangers) and six 2-hanger countershafts. The cost of the 20 horse-power motor for group drive is assumed as $297, and cost of the shafting and hangers, in place, as $210.

If, on the other hand, the eleven machines were operated by individual motors, the following table shows the size and speed that would be recommended for each machine.

Machine.	Motor. H.P.	Motor. R.P.M.
30-inch single surfacer	7½	1,120
8-inch four side molder	7½	1,120
16-inch hand feed rip saw	5	1,700
20-inch swing cut off saw	3	1,700
Single spindle shaper	3	1,700
18-inch jointer	3	1,700
Tenoner	3	1,700
Mortiser	2	1,700
Jig saw	½	1,700
Drill	½	1,700
Double emery wheel	½	1,700

The cost of the eleven motors for individual drive is approximately $848.10. The fixed charge has been figured as 15 per cent, which, for this class of service, should cover depreciation, interest, taxes and insurance.

It is assumed that, with individual drive, when the machines are not running the motors are shut down, while with group drive the belts are on loose pulleys. The proper motor losses have been added in each case. The friction loss in each bearing is figured as 100 watts and an idler pulley is considered as a bearing. The actual load on the machines has been assumed the same with both drives and consequently is neglected. Fig. 1 is based on the above assumptions and shows that for the plant in question the fixed and operating charges are lower for the individual drive, regardless of the machine hours per day, although for long hours of service the difference between the two drives becomes less. Practically all of the advantages from a production standpoint are with the individual drive so that there is very little excuse for using group drive in this case.

Fig. 2 is an extension of Fig. 1, and has been made to show the effect of the power rate on the relative advantages of the two systems of drive for various hours use of machines per day. From this curve it is seen that if all the machines worked six hours per day, or had a time factor of 60 per cent, that for all rates of one cent and above the advantage is in favor of the individual drive. For long hour service and very low rates the group drive has a lower total cost.

Both of these curves show that there is no sound reason for using group drive throughout in planing mills, and the example taken is entirely characteristic of this class of plants. Of the five factors mentioned in the early part of this article, all but the last one, maintenance, are graphically represented in Figs. 1 and 2. The plant with group drive has a total of 72 feet of shafting, 20 hangers, 11 idlers and 18 belts, while with individual drive there would be at the most 11 belts and no overhead hangers or belts. To any one familiar with shop maintenance it is not difficult to see on which side of the book the balance for maintenance will be.

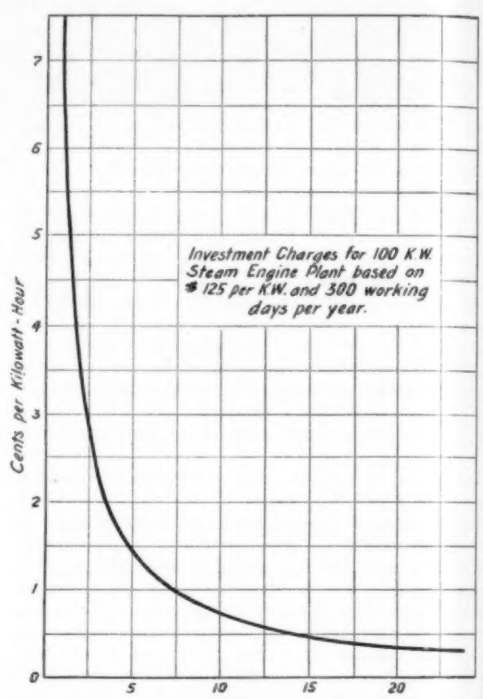


Fig. 3.—Investment Charges.

Although a concrete example was taken in order to obtain definite figures for the curves the same reasoning might be applied to plants of any size or in any industry. In large plants both individual and group drives are often used, the choice depending on the nature of the work done in the machines, the number of hours use per day and other factors as previously mentioned. It should be always borne in mind that the question of production predominates but that the actual power saving in individual drive by eliminating shafting and belts is sufficient to pay much more than the fixed charges on the increased investment.

THE COST OF POWER.

For the power supply for any industrial plant there are two possible sources; a private plant or a central

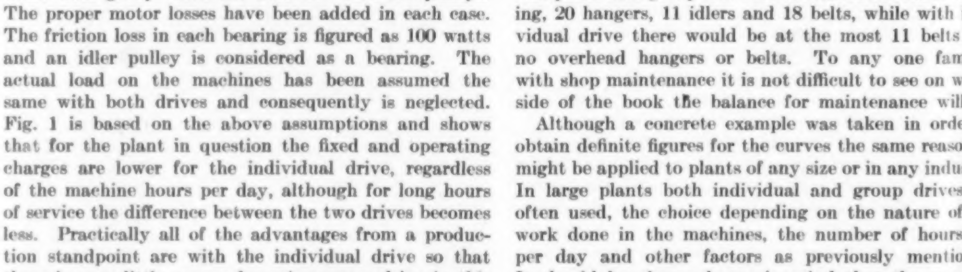


Fig. 2.—Relative Annual Savings.

* Reprinted from the Proceedings of the Engineers' Society of Western Pennsylvania.

station. In most cases there is no question regarding the reliability of the central station power and the only factor tending to retard its use is the rate. Owners of private plants often declare that they can make power much cheaper than they can buy it from a central station. The reason for this statement is in most cases that the owner of the isolated plant really doesn't know what his power costs him. The central station exists solely to manufacture and distribute power and has an organization especially trained for that work. The owner of the isolated plant is in business to manufacture some commodity and the manufacture of power is entirely outside of his regular business. His time could be spent to much better advantage in the business for which he is specially trained and which is producing dividends for him. Why should he manufacture electric power any more than manufacture his own gas, or pump his water when all are available and delivered at his door, with service which is both reliable and economical?

Large central stations with most improved machinery may be installed for $60 per kilowatt but for small industrial plants, say of 100 kilowatt capacity, the investment may reach $150 per kilowatt. Let us consider for example a 100-kilowatt steam engine plant having an investment of $125 per kilowatt and a yearly charge of 17 per cent or $21.25 per kilowatt. This charge is made up of depreciation 8 per cent, interest 6 per cent, taxes, insurance, etc., 3 per cent. Some people are inclined to allow even greater than 6 per cent interest since the power plant is part of the factory and money invested there is expected to produce better than 6 per cent.

On the basis of 300 twenty-four hour days per year of full load operation, the investment charge is 0.295 cents per kilowatt-hour. Fig. 3 shows how the charge per kilowatt-hour increases as the hours of full load operation decrease. For ten hours of full load operation the cost per kilowatt-hour due to investment is 0.708 cents. As previously stated very few plants operate at 100 per cent load factor so the above charge must be corrected for the existing load factor.

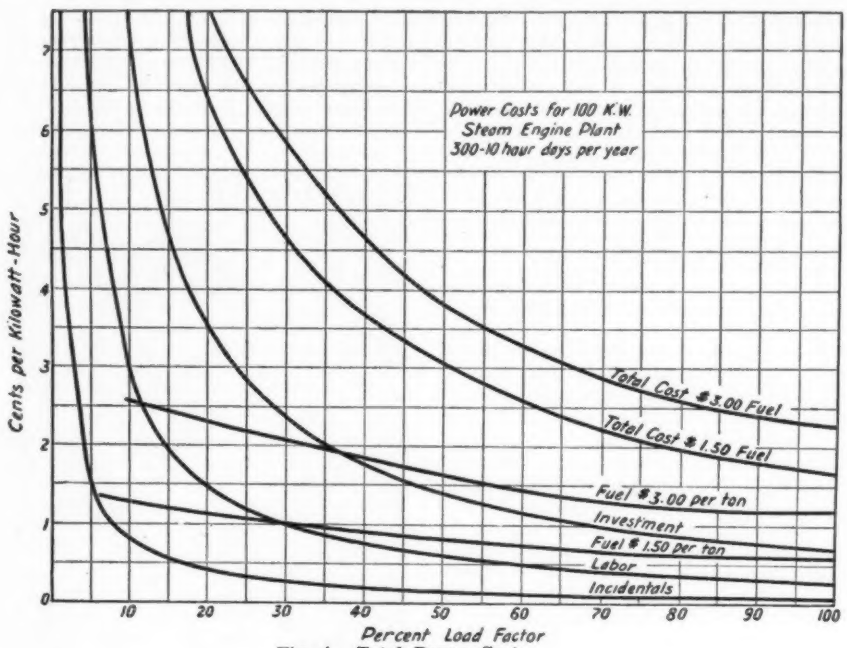


Fig. 4. Total Power Costs.

In Fig. 4 the effect of plant load factor on the investment charge is shown and is based on full load operation for ten hours per day. Since only one generating unit is considered in the present case the variation in load must be taken care of entirely by the governor so the coal consumption is shown as increasing with decreasing load factor. A full load efficiency of 8 pounds of coal per kilowatt-hour is assumed and a rate of $1.50 per ton for coal, which is a fair average for Pittsburgh and vicinity. Another fuel curve based on coal at $3.00 per ton is also given together with a total cost curve under these conditions. From the two total cost curves it is seen that at 60 per cent load factor a reduction of 50 per cent in the price of coal reduces the total cost of power about 21 per cent.

It has been considered that an engineer with a salary of $75.00 per month could operate the plant and that the incidentals as oil, water, waste, etc., would average $20.00 per month.

On the above basis the four curves for fuel, investment, labor and incidentals have been plotted and total power cost is the summation of the four. With a load factor of 100 per cent for ten hours the power cost (coal $1.50 per ton) is about 1.7 cents per kilowatt-hour, while for a 60 per cent load factor it is 2.6 cents per kilowatt-hour. Even in the above discussion many items have been omitted such as superintendence or the time that the $5,000 manager applies to power problems. The time and production lost due to breakdowns or late starts should also be charged but these items have to be obtained in each individual case.

From the above consideration the effect of decreased hours of full load service together with the effect of load factor on the cost of power are clearly shown so it should be fairly clear that the central station which operates 24 hours per day can produce power cheaper than a private plant operating ten hours per day. The question of load factor affects the central station in just the same manner as private plants and in order to increase their load factor, central stations make very low rates for off-peak loads. This load can be carried without additional equipment and investment charges so it is to the advantage of the consumer to avail himself of the low power rates during these times and by so doing still further raise the load factor on the central station and reduce cost of power to all.

A Scientific Study of Seasickness

And the Logical Remedy

Perhaps no malady to which mankind is subject is productive of so much real suffering, with so low a percentage of mortality, as the peculiar affliction known as seasickness, though it may be produced by many other agencies besides the tossing of ocean waves, such as the motion of railroad trains, see-saws, swings, "switch-backs," aeroplanes, or even camel-riding.

The many and various measures of relief urged on sufferers have been generally empirical and largely futile, because of a lack of comprehension of the essential character of the disturbance.

Latterly, however, a thorough-going study of the matter has been made, and the conclusions arrived at are very clearly summarized by Dr. Carl Ludwig Schleich in recent numbers of *Ueber Land und Meer* (Stuttgart, October to November). Dr. Schleich defines the illness as the spasmodic emptying of the upper portion of the alimentary canal by the pressure of the abdominal walls and the diaphragm, the action being occasioned by the irritation of the pneumogastric nerve. This convulsive action, known as vomiting, is usually due to an irritation of the nerve-fibers in either the stomach or the brain by poison or mechanical injury. The peculiar feature of *mal de mer* is that it is occasioned merely by unaccustomed motions having nothing to do with the digestive apparatus. In other words, the nerve is irritated by a successive series of rhythmic shocks tending to disturb the equilibrium. Dr. Schleich draws a parallel between the production of a charge of frictional electricity by the continued rubbing of a glass plate, and the final reaction of retching or vomiting produced by the repeated excitation of the nerves. We read:

"Similarly, shock after shock, every up and down movement of the ship produces irritation after irritation in our nervous system, until the gradual accumulation of mechanical strains leads finally to a sort of 'explosion.' That is my apprehension of the matter theoretically; it is the irritation of the vomiting nerve (*nervous vagus*, or pneumogastric nerve), or its 'telephonic central' in the brain by irregular pendular movements. Every nerve offers a certain degree of resistance to irritation, and it is when this limit is passed that the sort of explosion commonly called 'reflex action' occurs. Seasickness is the final 'reflex' of the vomiting center caused by rhythmic excitation.

"These excitations may come from the intestines and other abdominal organs, from the brain, the eye, from the muscles or the vasco-motor nerves of the skin, from spasm or cramping of the blood vessels, from weakness of the heart and a lowered blood pressure, or even from emotions of the soul, such as fear, shame, or horror.

"The pneumogastric nerve may be irritated mechanically by rhythmic shocks of the brain, which is all too loosely hung in the skull, hence we have seasickness. (1) By irritation of the nerve at its exit from the skull. (2) From irritation of the nerve endings by reason of the pendular swinging of the intestines and other abdominal organs, where these are too heavy or have overlong suspensory ligaments. (3) From shocks to the ganglions in the skin of the abdomen, which predispose the vomiting center to reflex action. (4) A special sense of equilibrium is located in the semicircular canals of the inner ear—an 'apparatus of orientation.' Rhythmic shock of these canals, which are filled with a lymph in which float the fibers of the auditory nerve, is a frequent excitant of the reflex action of the *nervus vagus*.

"Furthermore the shaking of the brain itself may lead to a sudden convulsive cutting off of the blood supply, as indicated by Albert's experiment with hammer strokes on the skulls of animals. But an excessive lack of blood immediately affects the vital core of the pneumogastric nerve—so we have (5) the emptiness of the blood vessels as a cause of irritation. Such a condition may also be caused by a convulsive contraction of the sheath of the nerves supplying the blood vessels. And (6) there may be an irritation of the optic nerve."

It is obvious that there can be no universal remedy for a condition so variously produced. There are various remedial measures, however, which may be adapted to special cases with more or less success. The best of these, of course, is the accustoming of the body to sudden shifting of the center of gravity, with the corresponding change of equilibrium. This is indicated by the immunity of sailors when they have once gained their "sea-legs," and also by the remarkable fact that newborn babes and nurslings are not affected, which is explained by the circumstance that the necessary handling, nursing, lifting, laying down and carrying of them habituates them to a constant shifting of the center of gravity.

For travelers not thus seasoned, each case must be separately studied. For persons especially sensitive Dr. Schleich advises a preliminary sedative such as, veronal, medinal, aspirin, or in extreme cases, even morphine or opium, or some other temporary narcotic which may induce a natural sleep.

Such cases, in which it may even be a matter of life and death, are of course subjects for the professional care of the ship's surgeon. Where there is a weak heart and low blood pressure a mild stimulant is advantageous.

"For some people a good breakfast with a glass of port or cognac is sufficient; for others a few drops of valerian may be good. Obviously this gentle stimulation of the heart is of use only where there is a disturbance of the circulation predisposing to seasickness through contraction of the blood vessels and consequent lack of sufficient blood supply to the brain. Such individuals should always assume a recumbent position in rough weather, with the head low."

To lessen the nerve-irritation due to the movements of the abdominal organs, which follow every motion of the ship, it is stringently recommended to lie prone and to support the abdomen by firm bandages, belts, or cushions. Dr. Schleich also found rhythmic breathing corresponding to the alternating motions of the ship of much benefit. It is often useful to lie in a tub of water, since the water absorbs much of the shock. It is noteworthy, in this connection, that swimmers are never seasick, no matter how rough the waves with which they are battling, and the same principle is being applied in the construction of modern cabins on the more luxurious and expensive ships by means of swinging tanks, which causes Dr. Schleich to predict that eventually seasickness will be unknown to the wealthy, though "the greater majority of poor devils will still have to depend on their best friend, the ship's surgeon."

The writer closes with the remark that seasickness in its worst stages takes on a direct similarity to cholera; "there is finally the absolute apathy, the dull indifference to anything that may happen."

Fountain Pen Manufacture*

Making the Iridium-tipped Gold Pen Points

By Douglas T. Hamilton

The life of the ordinary steel pen is of short duration as compared with the gold iridium-tipped pen point used in Waterman's Ideal fountain pens. The reason for this is that gold does not corrode or oxidize like steel, and that its wearing qualities are increased by

Fig. 1.—Melting the Gold for the Pen Points.

iridium, which is the hardest known metal. Other interesting facts concerning the manufacture of this fountain pen, especially the gold pen point, and the ink used in it, are given in the following article:

ALLOYING AND MELTING THE GOLD FOR PEN POINTS.

The gold for the pen point is received from the United States assay office in bricks 24 carats fine, measuring about 2½ inches long by 1½ inch wide by ¾ inch thick. Each of these bricks is worth anywhere from $500 to $1,000, according to its size. Twenty-four carat[1] gold

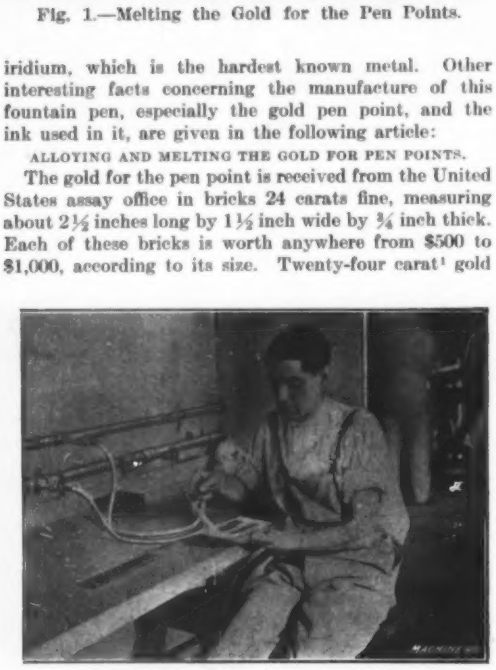


Fig. 3.—Fusing the Iridium on the Gold Pen Points.

is far too soft to use for fountain pen points, so it is necessary to alloy it somewhat, to make it harder and stiffer. The fine gold is melted with the alloy in a crucible, as shown in Fig. 1. Here the proper proportions of gold, silver and copper are mixed in, the amounts being 233½ pennyweights of fine gold (24 carat), 92 pennyweights of fine silver and 76 pennyweights of fine copper. This, when cast, produces a block 10 inches long by 1 inch wide by ¼ inch thick, weighing 401½ pennyweights. The reason for making a block of this weight is that when it is rolled out to the proper thickness it makes a sheet which can be conveniently handled. This alloyed gold is 14 carat, which is the standard for fountain pen points.

Following the production of the block which is cast in the iron box A, Fig. 1, the block of gold is conveyed to the rolling department, where it is passed through steel rolls from fifteen to twenty times until it is rolled out into a sheet of the required thickness. Rolling hardens the gold somewhat, and if carried too far without annealing is likely to produce cracks; it is therefore necessary to wind up the rolled sheet, and put it in an annealing furnace, where it is heated to a dull red, after which it is taken out and allowed to cool off gradually. The sheet is annealed twice before it is rolled out to the required thickness—about 1/64 inch. The blanks for the pen points are again rolled out to the exact thickness, after the iridium has been fused onto them.

CUTTING THE BLANKS FOR PEN POINTS.

After rolling the gold to the correct width and thickness, the strips are taken to the foot-presses, one of which is shown in Fig. 2. The blank is cut out by means of a blanking punch and die to approximately the required shape. After blanking, the pen point is taken to a miniature milling machine, where a narrow ledge is milled across the point, the object of which is to form a seat for the iridium to be fused on.

THE DISCOVERY AND CHARACTERISTICS OF IRIDIUM.

In 1803 Smithson Tennant found that the metallic residue which remains when platinum ores are dissolved contains two elements, to one of which he gave the name "iridium" on account of the varying color of its salts, and to the other "osmium," from the Greek, a smell, because of the peculiar odor which its volatile oxide possesses. Iridium is found in platinum ores in considerable quantities in the form of the alloys, platiniridium and osmiridium. The first of these occurs in grains and frequently in small cubes with rounded edges. Iridium is one of the hardest known metals and costs $1,500 a pound. It is secured in the Ural Mountains on the border of Asiatic Russia.

The atomic weight of iridium, taking hydrogen as 1.008, is 191.5. The specific gravity is 22.4 and the point of fusion is between 1,950 deg. Cent. (3,542 deg. Fahr.) and 2,200 deg. Cent. (3,992 deg. Fahr.). Iridium is very brittle when cold, but at white heat is somewhat malleable. The specific gravity of the fused metal is 22.15. The extraction of iridium is carried on in a manner somewhat similar to that used for other precious metals. The processes used in the extraction of the platinum alloys can be found in the majority of up-to-date books on chemistry. Iridium can be fused and volatilized in an electric furnace.

Gold pens have been found to resist the friction and wear incident to writing, as they glide over the paper better than pens made from any other metal. Gold is also used chiefly because of its non-corrosive and non-oxidizing qualities. Gold alone, however, is soft and will not last long. Before the adoption of iridium, the gold pen point was tipped with diamonds or rubies, which of course made the pen very costly. It was found, however, that iridium could be fused with the gold and a much stronger and more durable pen point produced.

TIPPING THE GOLD PEN POINT AND RE-BLANKING.

A granule of iridium, about 1/16 inch square or smaller, according to the width of the point, is fused onto the gold pen. For stub pen points two granules are used, one on each nib. To accomplish this the operator dips a camel's hair brush in the fluxing fluid and applies this to the nibs. Then he takes a granule

Fig. 5.—Stamping the Name on the Gold Pen Point in a Screw Press.

of iridium, holds it on the pen with a pair of tweezers and locates it by means of a magnifying glass in the correct position. The pen points with the iridium granules on them are then placed on a charcoal block. The operator now, as shown in Fig. 3, fuses the gold around the iridium by means of a gas and air-torch,

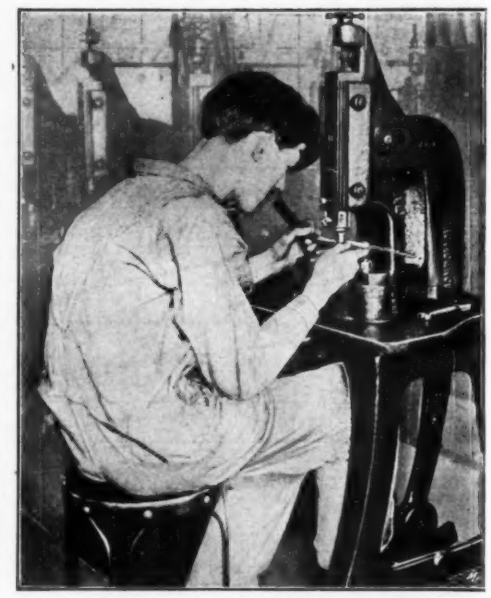


Fig. 2.—Blanking the Gold Pen Points in a Foot Press.

thus retaining it in position. The reason for forming a seat on the pen for the iridium is that the pen can be ground down flush on its under surface and still have a layer of iridium to protect it and to increase its wearing qualities.

The blank up to this operation is considerably thicker than is necessary for the finished pen point, and to reduce the blank to about 0.008 inch thick, it is passed through a small pair of steel rolls. A horizontal slit is cut in the upper roll in which the granule of iridium

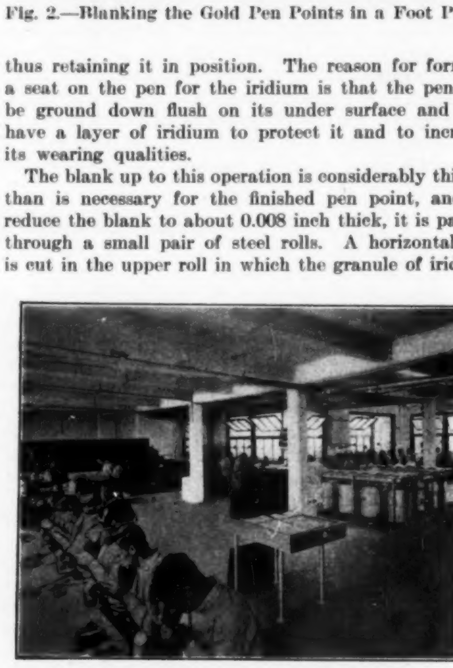


Fig. 4.—General View of the Gold Pen Point Grinding Department.

fits, so that it will not be broken during the rolling operation. It is necessary to roll out the blank to give it sufficient resiliency, because the fusing on of the iridium granule anneals it. The shape of the pen point after rolling is distorted, it thus being necessary to blank it out again. This is done in the foot-press shown in Fig. 2.

After trimming, the heart-shaped hole A, Fig. 7, from which the slit forming the nibs extends, is cut in the pen point. Then the number and trade-mark are stamped in the pen point, in the screw press shown in Fig. 5, after which it is formed to the shape shown in Fig. 7, by a forming punch and die held in a screw press.

SLITTING THE PEN POINT.

The next operation consists in slitting the pen point to form the nibs. This is accomplished in the manner shown in Fig. 6. The pen point is held in a pair of tweezers A, which are supplied with a rubber handle. The operator grips these tweezers in his right hand, allowing them to rest on the support B. The pen point C is then brought into contact with the rapidly revolving copper disk D, which is 3 inches in diameter by 0.0055 inch thick, and rotates at 4,000 revolutions

* Reproduced from *Machinery*.

[1] The word carat as applied to gold means the twenty-fourth part and is used to designate the proportion of pure gold. The gold used for commercial purposes is not pure, but generally contains a certain proportion of silver or copper. Pure or fine gold is called 24 carat, but when it contains ten parts of silver, copper or other metal, it is called "14 carat gold," because only fourteen parts of the whole is pure gold. The alloy used for Waterman's fountain pen points consists of 14 parts pure gold, 5.5 parts silver and 4.5 parts copper. This alloy is called 14 carat gold.

per minute. The disk is punched out from a copper sheet of the required thickness, and projects about 3/8 inch above the supporting washers *E*, which steady it while slitting the pen point. Of course this disk rotates at a high speed and it requires considerable pressure to deflect it. The pen point is held on the disk by the operator, so that the slit will come directly in the center of the heart-shaped hole.

The copper disk *D* is coated with superfine emery, mixed with oil which is applied to it by means of a piece of felt fastened to a stick. It is impossible to slit a gold pen point tipped with iridium in the same manner as a steel pen is slit, because the iridium, on account of its extreme brittleness, would fly into fragments, if a slitting punch and die were used. The emery-coated copper disk, however, works very effectively and cuts through the iridium so easily that it seems to require no special effort at all on the part of the operator.

The slitting of the pen point, however, requires considerable skill, as the slot between the nibs must be perfectly straight; that is, if the slot is on a slant, the nibs will interlock as shown at *B* in Fig. 7. This causes one nib alone to bear on the paper and prevents sufficient ink from reaching the point; in fact, the pen will hardly write at all. However, this can be rectified when grinding, as will be explained later.

GRINDING THE PEN POINT TO THE DESIRED SHAPE.

The operations previous to grinding require considerable skill on the part of the operator, but the grinding of the pen point is really the most important one of all. In this operation the pen point is given its final shape. The operator holds the pen point *A* in a pair of tweezers, as shown in Fig. 8, and applies it to an emery-coated copper wheel *B*, which is provided with four different diameters, so that each part of the pen point can be ground to the required shape. This operation is so important and requires such skill that the shaping of the pen point cannot be watched by the naked eye, but requires the aid of a powerful magnifying glass. The operator grinds a little, removes the dirt from the pen, and then looks at it with the magnifying glass shown at *C*.

The slit is also squared up in this operation, so that the nibs will pass by each other freely without interlocking. The disk shown on the left end of the spindle, which is 3 inches in diameter by 0.007 inch thick, is used to square up the slit. This disk is made from taggers iron[3] and is coated with superfine emery applied with a piece of felt. The shape of the slit is clearly shown at *C* in Fig. 7. As will be noticed, it gradually increases in width from the point until it reaches the heart-shaped hole *A*.

A general view of the gold-pen grinding department, in which the grinders are seen at work, is shown in Fig. 4. In this illustration can also be seen the washing troughs and the cans used in collecting the gold dust which adheres to the hair and hands of the grinders.

SETTING THE PEN POINT.

Each shape or grade of pen point requires a different "set," so that it will feed the ink freely and evenly. A stub point—another name for a wide-pointed pen point—must have less resiliency than a fine point, so that the former will feed the ink much more freely than the latter. This "set" to the pen point is accomplished by hand. The setter grips the pen point between the first finger and thumb of both hands and moves the nibs back and forth past each other. Bending the nibs back and forth in this manner stiffens them and gives them greater resiliency.

[3] Taggers iron is the name given a class of very thin sheet iron, about 0.007 inch thick, which is used largely for metal tags, and no doubt derives its name from its use. This grade of sheet iron has a slightly mottled appearance owing to the oxide adhering to the surface. It is a special grade of Russian sheet iron produced by hammering a pile of heated sheets having slight projections or indentations on its surface.

The desired set is a matter of "feel" only. The setter, after moving the nibs back and forth, holds the nibs under a jeweler's magnifying glass, and slightly depresses the frame of the magnifying glass on the nibs, spreading them apart. The amount of pressure required to separate the nibs is all that the operator goes by in setting the pen point. It can, therefore, be seen that setting the pen point is a matter of experience only, and the setter must thoroughly understand the action of the nibs for the different grades of pen points. Besides setting the pen point, the setter also smooths it up on superfine emery cloth so that it will write freely without scratching, all sharp corners being removed. The setting and final touching up of the pen point is the last operation.

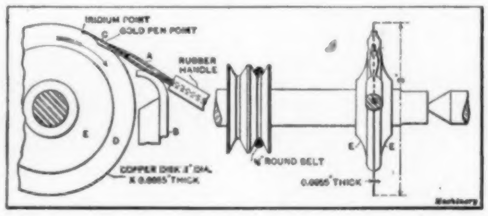


Fig. 6.—Slitting the Gold Pen Point on an Emery-coated Copper Disk.

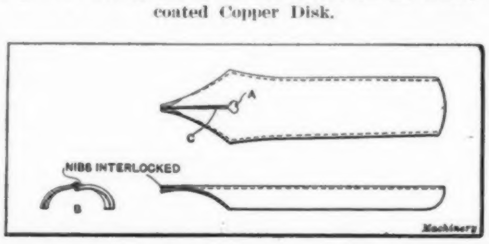


Fig. 7.—View Showing the Action of Improperly Slitted Nibs.

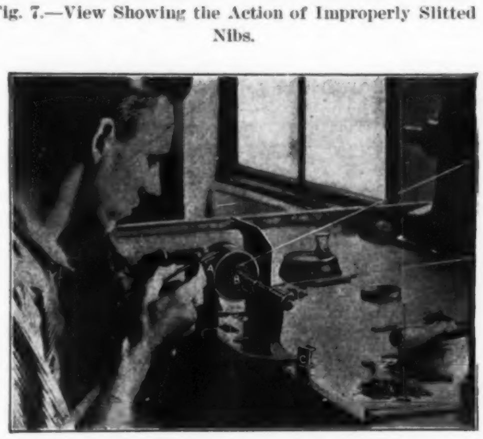


Fig. 8.—Grinding the Gold Pen Point to the Desired Shape on Emery-coated Copper Wheels of Various Diameters.

ASSEMBLING THE PEN POINT—FEED AND POINT SECTION.

To assemble the pen point and feed in the point section, the operator places the feed on the pen point, so that by looking down on the top of the latter the feed can just be seen projecting slightly in advance of the curved section of the pen point. The pen point and feed are then placed in the point section, and the latter is screwed into the barrel. The assembled pen is now held over a Bunsen burner to soften the rubber feed slightly. The feed is then pressed down on the pen point so that there will be no space at all between them. To see that the feed fits properly, the operator inspects it by means of a magnifying glass. If there should be a space between the under side of the pen point and the feed, the pen would overflow, which, no doubt, has been the experience of many a novice who has attempted to place a pen point in the point section.

The sectional view of the assembled pen, Fig. 9, shows the feed and pen point placed in their proper positions relative to the point section. This illustration also shows the twin rivet used in holding the clip-cap to the rubber cap. The ball is swaged onto the clip-cap instead of being soldered, as was the practice formerly followed.

COLLECTING THE GOLD DUST.

The gold dust which results from grinding and working 14-carat pen points is worth about $12 an ounce, and as over 1,500,000 pens are turned out per year, it is evident that the waste is considerable. The sweepings from the grinding-room floor alone are sold for $4,500 a month, while over $500 worth of gold is reclaimed each month from the water in which the grinders wash their hands and faces. Every grinder is supplied with a new pair of overalls each "clean-up," and the old ones, which are burned, return as much as $5 in gold dust—a case where use increases the value.

FOUNTAIN PEN INK.

As the L. E. Waterman Company makes its own fountain-pen ink, it may be of interest to give a short description of the materials used and the methods of manufacture employed. The ordinary writing fluid is, as a rule, not clean enough to give good results in a fountain pen as it clogs the feed, causing the ink to flow unevenly. Fountain-pen ink consists mainly of tannic acid, gallic acid and water. The tannic and gallic acids are obtained from a peculiarly shaped nut, called "nut-galls," which is deposited by an insect on the leaves of trees in Asia Minor. These nuts, when received at the factory, are crushed and put in a percolator, where water is poured on them. The fluid from the percolator is boiled to extract the acids, after which an aniline coloring matter and other chemicals are mixed in with the acids to produce the record inks, as well as the various colored inks.

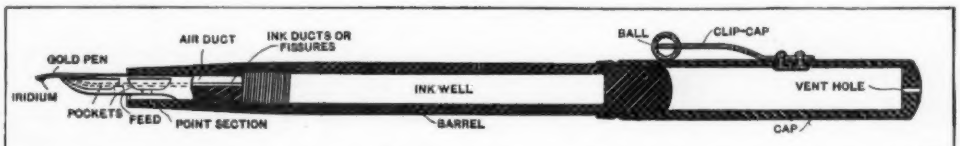


Fig. 9.—Sectional View of L. E. Waterman's Ideal Fountain Pen.

Phosphoric Acid and the Quality of French Wines

PATUREL, who is chief of the agronomic establishment of the Saone and Loire district of France, brings out some striking observations as to the relation between phosphoric acid and the quality of wines. The first idea of a relation between the general quality of wines and their richness in phosphate principles was developed by the researches of Prof. Müntz. After he had made a series of analyses bearing upon the products of different vine-growing regions of France, he found that the superior quality coincides with a greater proportion of nitrogenous matter and phosphates, and there appears to be an influence brought about by these bodies upon some of the properties of wines which give them differences so great in value. The author has been engaged on this question for the last ten years and sought to verify the exactness of this statement as to the effect of phosphates. He limited his researches to the wines which were produced by a single region. Since 1901 he made analyses of products from the region of Macon, taking his samples at the time of the annual concourse organized by the local agricultural society and analyzing about 41 samples each year during 9 years, or a total of 367 samples. The amount of phosphoric acid varies between 0.012 and 0.030 per cent for the mean annual result. He analyzes four different commercial qualities of wines, and finds without exception that the amount of phosphoric acid is greatest in the first class and grows less in the other classes, following the same order. These results hold good in spite of the great annual variations in the real amounts of phosphoric acid in the wines. For instance in 1906 the general quality was good, and he finds 0.0394; 0.0334; 0.0265 and 0.0239 per cent for the four classes; in 1905 the quality was inferior, and the result is, 0.0162; 0.0134; 0.0113; 0.0050. This shows that the quality of the wine always follows the percentage of phosphates, regardless of the fact that in one year the general quality may be good and in another inferior. Such a coincidence even with widely varying qualities of product, is remarkable, and there appears to be no doubt that the relation holds good. Another check upon these results is given by noting the average amount of phosphoric acid in the four classes. In 1901 it is 0.018; in 1902 it is 0.023 per cent, and so on for the eight years of the tests. It now remains to find whether in fact the quality of the wines for these years as recognized by the dealers will follow the order of the table. That is, if the table shows that the theoretical values vary irregularly from one year to another, the values observed upon the market should be in the same order. The author addressed himself to three of the principal dealers of Macon and asked them to state the average quality of the products for each of these eight years, from their own observations. The results which they gave, noting each year's product as superior, good, passable or inferior, are remarkably in concordance with what the author found from his table of figures. In this way the relation appears to be quite clear.

The present method appears, therefore, to be a valuable one, as it not only allows of the estimating the quality of the products for a given crop, but also to establish an exact classification of the general value of successive yields. We may conclude that the best characteristic of the quality of wines is given by their richness in phosphates, and this idea is much superior in this direction than the indications which are given by the percentage in alcohol and other elements usually taken into account. In this way it is possible to keep an estimate of the value of the phosphoric acid in the products of any given region, and by pursuing a series of researches during a number of years under conditions which are always similar, many data can be tabulated which will be of great value to the general quality of the wines of that region.

We have here another example of the value of modern scientific methods as an aid to one of the oldest and seemingly most elementary of industries.

The Problem of the Railway Rail

By Robert G. Skerrett

On the 25th of last August, a train on the Lehigh Valley Railroad, laden with excursionists, was wrecked through the fracturing of a faulty rail, resulting in the death of twenty-eight persons and the injuring of sixty-three others. The accident happened near a steel girder bridge spanning Canandaigua outlet, and some of the derailed cars were thrown off the bridge and into the creek.

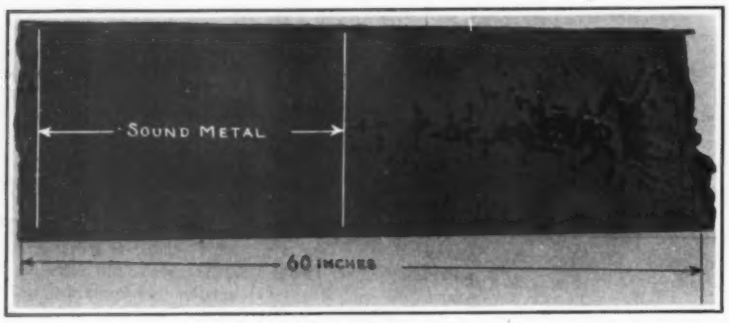


Fig. 1.—A big 3-ton Bessemer rail ingot. This ingot has been split through the middle lengthwise in order to disclose the full extent of the "pipe" and its recurrent tailings. Less than half of this ingot is fit to be rolled into rails. In practice, however, probably all but ten or fifteen per cent of the defective top would be used in the rolling mill in making rails.

Fig. 2.—A 3-ton ingot which has been rolled into a bloom by nine heavy passes through the rolls. The pipe is still distinctly visible throughout the greater part of the bloom, but there are intervals of sound metal between the defects. It is when the cutter shears the bloom at these sound points that he makes the fatal mistake of concluding the rest of the metal to be perfect. Thus defective rails are turned out. The whole of this bloom should be condemned so far as its fitness for rails is concerned. The subsequent passes that actually form the rail are too light in their pressure to close up the "pipe" and tailings.

The train was drawn by two locomotives and was making probably not more than twenty-five miles an hour at the time of the disaster.

The broken rail was of 90-pound type and was manufactured by the open-hearth process—the ingots being cropped with a 20 per cent discard. The rail came from the A or first section of the ingot to be rolled. At the time the rail was placed in the main track it was 30 feet long, but, proving defective, it was shortened 10 feet at one end and relaid. It was supposed then to be sound for the remaining length. When this rail gave way, at the time of the accident, it broke into something like seventeen pieces, and evidences of defective structure in the form of "pipe" were discernable at every cleavage. The railroad company was aware that there were in service defective rails similar to the one that failed with such disastrous consequences, and the officials had directed that such rails be removed wherever discovered and before the trying period of cold weather should set in, when the rail is more apt to fracture under the pounding of the driving wheels of a speeding locomotive.

From the official report of the specialist employed by the Interstate Commerce Commission in this instance, we learn that the rail that failed showed "transverse fissures" in the head, and we are told that defects of this kind are especially dangerous since they develop after the rail is laid and are not as readily detected as "piping." The investigator, Mr. James E. Howard, suggests that these tranverse fissures indicate that the limit of wheel pressures has been reached—if not exceeded, and that the accident in question and others of a similar character point to the need of a change of form in rail heads in order to meet the present loads imposed by our heavy and high-speed traffic.

It is a well-known fact among the makers of higher carbon steels that it is disastrous to work the metal, especially by forging, after the material has chilled to a certain point below a welding heat, because incipient defects like "pipe" or shrinkage cracks born originally in the ingot become either star cracks or deeper longitudinal cleavages—varying with the nature of the original ingot defects. The rail in question, according to the contract specifications, had a carbon content of from 0.70 to 0.80 per cent, which may properly be called high. The fact that this rail came from an ingot that had already had 20 per cent of the defective end discarded, and that after laying, it was reduced one-third in length because of "piping," removes much of the suggested mystery with which the "transverse fissures" are seemingly surrounded in the present case. We have a rail of high carbon, we have a rail with extensive "piping," and after several months' service it succumbs under the joint poundings of the drivers of two locomotives proceeding at the moderate speed of twenty-five miles an hour. The incipient fractures represented by the "piping" were simply hammered into more dangerous cleavages by each passing train, until the rail was virtually shattered into many fragments. Someone may say, "But there were transverse fissures, and these are quite different from the fractures due to 'piping.'" Again this is an error, and the physical get-up of the present form of rail will show why. The modern practice in increasing the rails from 70 pounds upward to the present maximum of 100 pounds per yard is to provide principally more metal for the upright thin web which rises from the foot of the rail and supports the head. The height of this web is intended to give stiffness to the rail so that it will not flex as is the wont with rails of lesser depth, thus reducing the cutting action upon the underlying wooden ties and providing a more rigid travelway for the trains. Considering this web, then, virtually as an anvil and the most unyielding part of the rail, naturally any incipient cleavage in the head, under successive blows, would expand or spread in the direction of least resistance, which would be laterally, producing transverse fissures. This is especially apt to be the case if the original defect is "pipe" which has not welded because of oxidized surfaces. It is said that an analysis of the defective part of this particular rail showed the "piping" to be due to slag originating in the furnace, which was carried into the ingot at the time of casting. Slag as such, does not produce "pipe," but because it is lighter than the steel, it will follow upward as the ingot freezes and, quite likely, will be found adjacent to the "pipe" as the latter is the last part of the casting to solidify.

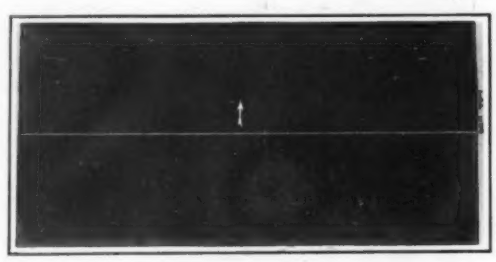


Fig. 3.—This is part of a bloom, the ingot after having been subjected to the nine heaviest or most compressive passes, showing the presence of pipe which has moved upward because the ingot was too hot and was laid on its side.

Fig. 4.—A cross-section of a regular steel rail which has been polished and then etched with iodine. This brings out the different constituents of the steel and shows their distribution. In the present case it is plain that the rail has been made from steel whose ingredients are unevenly distributed—thus producing a rail of uncertain quality and variable strength. The small white arrows show the position of hidden "pipe."

Dr. Dudley has clearly shown (Fig. 5) that the granules of entrained slag acted virtually like wedges, being driven vertically downward under the succeeding blows of the passing wheels, resulting finally in the head of the rail being split, the cleavage passing more or less at an angle to one side or the other of the upper end of the web. The only lateral widening of the defect was found at the top of the slag wedge—the really dangerous fissures extending downward until the half of the rail head carrying the load was broken through. This distinction between the action of mere "pipe" and that of a trained slag can readily be grasped, because in the latter case we have a splitting instrument which naturally acts along the line of the impelling blows.

There is certainly food for thought in the official suggestion that something may have to be done in the way of modifying the form of the rail head to meet the exacting demands of the present traffic. As a matter of fact, the wheel loads are not applied symmetrically upon the rail head, as anyone can easily verify by observing that it is only the inner half of a new rail head that is polished bright by wear. Therefore, the rail is carrying the greater share of its burden upon one of its shoulders, so to speak, and at an appreciable distance out from the supporting web. This leverage, when allied with either "pipe" or slag, is sufficient under the accumulated blows of wheel loads to develop incipient defects into dangerous fractures, and the main problem, apart from the form of the rail head, is to make sure that the steel is sound from which the track is rolled.

During the investigation by the coroner immediately after the accident, the chemist of the Lehigh Valley Railroad stated: "I consider the *A* rail, after 20 per cent of . . . cropping, to be as safe as any rail in the ingot. . . . We find as a general practice that when 15 per cent is removed there is very little tendency to pipes or other defects in the steel."

The molten steel either from a Bessemer or an open hearth furnace is first poured into a large ladle, and then drawn off from the bottom and teemed into the molds. Because of the manner in which agitating air is blown through the Bessemer heat, slag is more apt to be intermixed than with the open-hearth process, but this slag

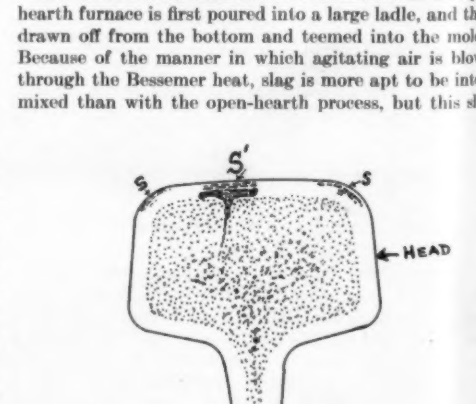


Fig. 5.—A graphic cross-section of a typical rail with deposits of slag in the head at *s*, *S'*, *s*. The tiny granules of slag act like wedges, and under the repeated blows of the passing wheels are driven deeper as shown at *S'*. Finally the metal is fractured and disaster invited.

will rise to the surface in the ladle if the metal be allowed to stand for a few minutes before teeming. Therefore, if proper care be taken, this slag should not be drawn off through the bottom nozzle of the ladle. "Pipe," on the other hand, is due to the shrinkage of the steel as it passes from the molten to the solid state. This is equivalent to a definite percentage, and the space so generated may be distributed between blow holes and "pipes" or entirely concentrated in the formation of the latter cavity—in which case it usually extends downward deeper into the ingot, thereby necessitating a greater percentage of discard in order to insure perfectly sound metal for working into subsequent product. The agents employed in cleansing the steel to get rid of oxygen while substantially eliminating blowholes incidentally augment the "pipe."

It may be asserted, without fear of justified contradiction, that there are no rail ingots being cast in regular practice to-day that have so moderate a depth of pipe that a discard of 15 per cent will remove all of the bad material, and emphasis is laid upon this situation by the fact that the rail that broke on the Lehigh Valley Road came from an ingot that was cropped 20 per cent, and we have seen how much imperfect steel remained to be rolled into the section in question. It is quite likely, even with the best practice and deliberation in rolling the rails—the latter being vital to their soundness—that a discard of at least 25 per cent would be an allowed minimum.

This question of sound steel has been examined by the Government with a good deal of painstaking thoroughness, and the results, broadly stated, show that defects in the ingot material remain defects in the finished product, and can be traced through every stage of development working. In 1909, the Ordnance Department of the U. S. Army made a series of tests at the Watertown Arsenal, and the findings have only recently been published. A number of acid Bessemer ingots were examined at every stage of their working so that a true line could be followed in checking up the evolution of the bloom and the forming of the rails. It is quite impossible here to go into the details of that exhaustive investigation, but bearing in mind the statement that a 15 per cent discard would insure sound rails from the rest of the ingot, the Government's findings are a disheartening revelation especially to us that may have to ride on the rails so made. The average carbon content was approximately between 0.55 per cent and 0.60 per cent, and this is a fair example of the general run of rails. Any increment in carbon tends to increase the percentage of "pipe." Fig. 1 shows one of these three-ton ingots cut longitudinally through the middle, disclosing the depth of defective metal. A discard of 50 per cent would be needful to insure sound metal for the after product. Fig. 2 shows one of these ingots rolled into a bloom—the stage immediately preceding the rail-forming operations of the rolls. The dark marks indicate "piping" and the amount of the bloom that should not be allowed to go into a rail. Again, we see how fatal a 15 per cent discard would prove. Fig. 3 is a portion of a bloom which was laid on its side when very hot, and we see how the center of the steel was still fluid because the "pipe" line moved vertically above the true center of the bloom. In this way defective material may get into either the head or the foot of the rail; but this flow of the metal indicates principally how important it is that the ingot should remain in a vertical position before rolling, long enough to make sure that the metal is generally solid, save, perhaps, at the extreme upper end and within the area to be discarded. Fig. 4 shows a rail section which has been polished and etched with iodine. This brings out the different constituents of the steel and shows their distribution. In the present example the rail was made from steel whose ingredients were unevenly distributed—thus producing a track section of uncertain quality and variable strength. This may be due to the haste with which the ingot is rushed through the various operations following its casting, and in some of our steel plants the amount of tonnage turned out daily is the main concern. The small white arrows show the position of "pipe" which has been rolled into the rail, and which is not visible externally except at the point where the section has been made for examination. Fig. 2 also shows us that there are points where the bloom may be cut crosswise without disclosing the unsound metal lying on either side. This emphasizes the importance of the utmost thoroughness in examining rails for defects, and points also to the unwisdom in accepting an arbitrary trade measure of discard.

Fuel Consumption and the Climate of Cities

A Study of the Effect of Fuel Consumption in New York City upon Temperature and Rainfall.

Attention has been frequently drawn, of late years, to changes of climate in the neighborhood of large cities In New York, for example, temperature records over a long period show a steady decrease in the number of occurrences of zero weather. Since 1903 the zero mark had not been again reached until this year. In recent years, also, records of precipitation show a steady decrease, from an average of nearly 45 inches for the 25 years previous to 1903 to a mean of 40.17 inches for the period 1903 to 1910, with a minimum last year of 33.72 inches. Reginald Pelham Bolton, in his presidential address at the July meeting of the American Society of Heating and Ventilating Engineers, suggests that the vast quantity of heat emanating from industries and from the heating of buildings is responsible for the climatic changes. We take, says *The Engineering Magazine*, a few paragraphs from his very interesting development of the subject.

"Exact statistics of the consumption of fuel within the boundaries of the city have not been recorded for any great length of time, but sufficient indication may be gathered from those recorded during recent years to indicate that the increase in consumption has kept pace with the vast growth of the population. The following details of the usage of coal in Greater New York are derived in part from the *Coal Trade Journal*, and in part from the public records. The generation of power for transit purposes in 1909 consumed 1,343,573 tons, and the electric lighting companies consumed 884,757 tons. The production of gas involved the distillation of 918,000 tons of coal per annum, from which 450,000 tons of coke are derived, of which 188,000 tons are consumed by the gas companies, and 271,000 tons distributed and added to the domestic fuel consumed in the Greater City. In addition to the fuel, 137,000,000 gallons of oil are used for gas enrichment, or a total weight of 512,000 tons; this is equivalent in heat value to coal of a weight of 768,000 tons. From these products there was made in 1909 an output of 36,500,000 cubic feet of gas, which was distributed and burned within the area of the Greater City. The production and consumption of gas, therefore, is equivalent to the heat value of a total of 1,686,000 tons.

"There are 50 breweries, consuming about 500,000 tons annually, and the fleets of harbor tugs and vessels are estimated to consume about 450,000 tons of bituminous coal. There are 745 private power plants in industrial, hotel and business buildings consuming about 2,200,000 tons. The domestic usage of fuel, in houses, stores and apartments, is by far the largest and best defined element, amounting to 6,380,000 tons. Sundry other elements bring the present annual consumption to a total of approximately 16,932,000 net tons.

"A proportionate addition for the consumption in Jersey City and its vicinity, in which a population of some 340,000 persons are resident, would add 1,250,000 tons. With the addition of the oil used in gas manufacture, the total equivalent in coal becomes 18,950,000 tons.

"The consumption of fuel has grown 23 per cent in five years, and its course shows a nearly parallel rate of increase with the growth of the population, doubtless due to the large proportion of fuel which is directly utilized for domestic purposes.

"With these figures in hand, we can arrive at some estimation of the vast quantity of heat communicated to the incumbent atmosphere, particularly during the heating season. From all the sources above described, there is cast up into the atmosphere a volume of heated gases, at an average temperature of fully 350 deg. Fahr., probably 18 times in weight that of the fuel consumed. To this volcano of heated gases is added all the exhausted steam, and the products of combustion of gas, all mingling directly with the atmosphere, and in addition the radiant heat and heat conveyed by convection from all buildings, all frictional sources, and dissipation of energy. The heat of condensed steam in power houses and that of all sewage is communicated to the waters within the area of the city, and is thus indirectly added to the heat-radiating effect.

"A not inconsiderable item is that of the animal heat of the population of 5,000,000 persons, which, upon the basis of an average emission of 200 heat units per hour per individual, would amount to 24,000,000,000 per diem, equivalent to the heat value of 438,000 tons of coal per annum.

"The portion of the city in which the fuel consumption takes place is practically that included within an area of 130 square miles. Within this area, during the winter heating season, about 80 per cent of all the fuel, and about 60 per cent of the oil is consumed. The average consumption of 85,830 tons per day, upon the basis of an average temperature of 40 degrees, leads to the extreme condition, when a zero temperature is approached, of a consumption of 214,560 tons per day.

"We may first consider the effects of the emission from the smoke flues and stacks of the gases derived from the combustion of this amount of fuel. Assuming the emitted gases to be 18 times the weight of the fuel burned, their daily volume would be 175,680,000,000 cubic feet, and if their average temperature be taken as 350 deg. Fahr., the heat contained would be 614,500,000,000 heat units. Such a heated volume would add 3½ degrees to the temperature of the atmosphere, for half a mile in height, over an area of 130 square miles.

"If to the volume of these gases of combustion, we add the radiant heat and that imparted by convection from all sources to which reference has been made, we find a total exceeding 4,000,000,000,000 heat units per 24 hours, which may be capable of increasing by a similar amount the temperature of a volume of air seven times greater than the foregoing, or would raise the temperature 4.94 deg. Fahr. over the entire area of the Greater City, 326 square miles, to a height of a mile. It would seem, therefore, that the first premise as to the effect of the heat emitted by the city in modifying the lower temperatures of the winter season, is substantiated.

"That this great emission of heat is also capable of producing some effect upon rainfall appears from the conditions disclosed by the records of precipitation. The mean annual rainfall of the city of New York is 44.1 inches, an average which, up to 1903, was fairly well maintained, the average for 25 years prior to that date being nearly 45 inches. Since 1903, however, the mean precipitation has fallen to 41.55, and the highest annual rainfall in that period, 1907, was only 45.28 inches. At the same time the number of cloudless days has considerably increased. Between 1889 and 1903, the highest number of such occurrences was 96; but since 1903 the highest has risen to 114, and the average has been 101.

"These are indications of a growing condition of dryness which appears to accompany a decrease in annual precipitation, which in 1910 fell to the unusually low rate 35.98 inches. Examination of the precipitation during the heating season shows that there has been a progressive decrease during the past 20 years, and since the winter rains are those which are least subject to evaporation, their reduction is likely to be productive of the condition of dryness from which New York is at present suffering.

"Assuming that the large volume of heat already described should be added to the incumbent atmosphere over the area of the city, or 326 square miles; for each degree added, the increased temperature of the air would add about 3½ per cent to the moisture-absorbing capacity of the atmosphere. It is evident that this great volume of heated air would, in the absence of wind, rise as do the gases emitted from the mouth of a volcano, and reaching a certain height, would spread and fall as they were gradually cooled by the cold blanket of superincumbent air or moisture laden clouds. The effect would thus radiate over a very considerable area, and would be productive of just such a variation of the conditions of humidity in the city and its surrounding district as appears from the records to have been gradually developing.

"So far as the rise of temperature is concerned, no other than beneficial results can be attributed to the dissipation of this vast amount of heat, but if the effect extends, as it must extend, into the absorption of moisture by the air which would otherwise have been deposited upon the area below it, then we shall find, in a reduction of winter rainfall over this area, a result which may have reached an appreciable point at the present time, and which, in the course of time, by the growth of the interference with nature, may become disastrous.

"That such an effect is now going on, would appear reasonable from the premises. The total heat emitted would raise the moisture-absorbing capacity of an envelope of air a mile high over an area of 326 square miles about 7⅓ per cent. Let us assume that the usual conditions preceding a rainfall are in progress. A gathering amount of humidity in the super-incumbent atmosphere has taken place, and a degree of saturation has been reached, of, say, 99 per cent, the temperature of the air being 42 deg. Fahr. At the approach of any cooler wind or other layer of air, the temperature would fall, and upon reaching 40 degrees, a condition of complete saturation would be reached and rain would commence.

"But meantime, the heat emitted by the city below is being continuously transmitted to, or radiated through the atmosphere below the rain clouds; and notwithstanding the fall in temperature of the super-incumbent layers, the rising column of heat has the power of increasing the absorbing capacity of the layer below, or of retarding the fall in temperature of the saturated air, so that the dew point is not reached. Under these circumstances, rain will not fall, though the atmosphere (for some distance above the ground) may be highly saturated.

"The figures cited indicate that the total heat emitted by the city in average winter temperature of 40 deg. Fahr., would add to the temperature 2 degrees over the area of the Greater City, 326 square miles, to a height of one mile, and would produce the effect of increasing the capacity for saturation of the mass of 48,000,000,000,000 cubic feet by a total of 1,440,000,000 pounds of water—equivalent to about 0.03 inch of rain over the entire area of the city.

"If these conclusions as to the association of the mechanical dissipation of heat with the vicissitudes of temperature and humidity in the surrounding atmosphere should be well based, then we must look forward to an increasing degree of artificial interference with the course of nature as the population of New York and its fuel consumption grow on parallel lines."

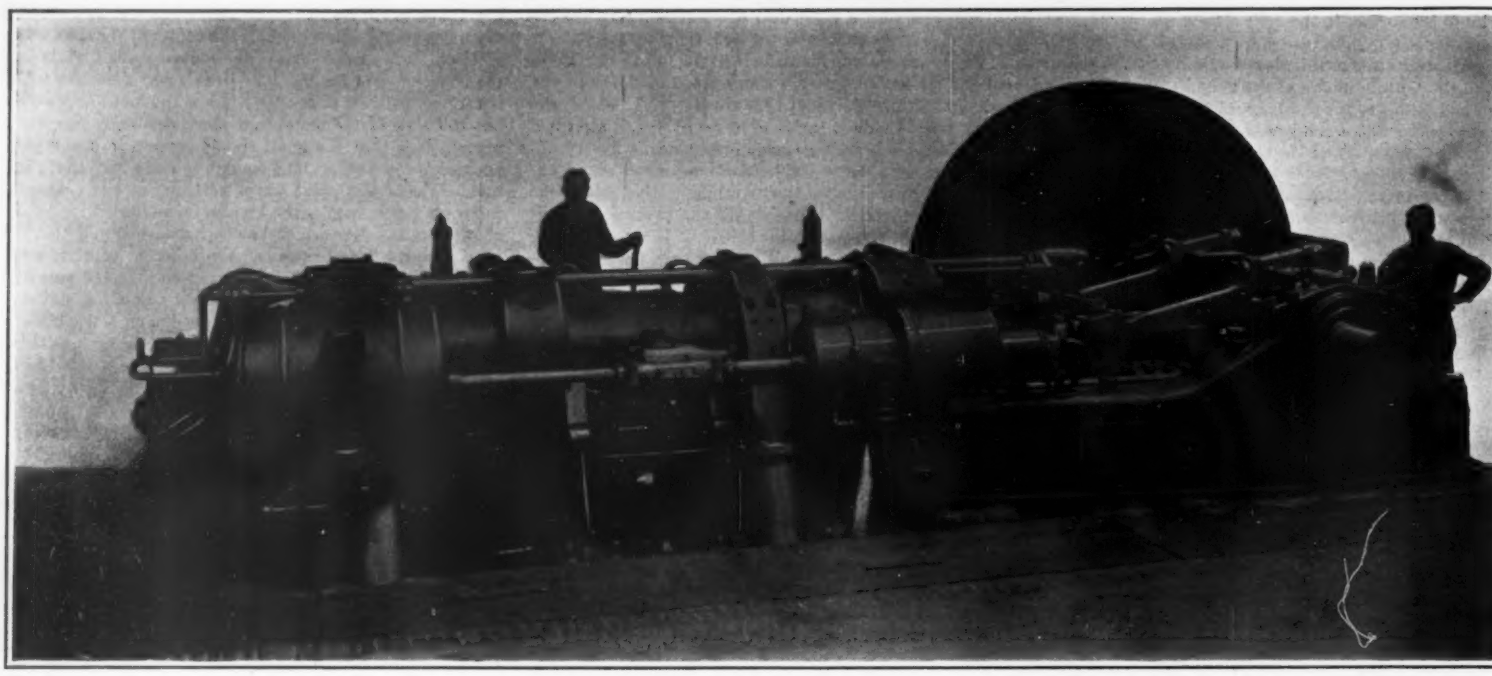


Fig. 1.—The Junkers Oil Engine (of the Diesel Type).

The Junkers Engine

A High-Power Oil Motor

By the Berlin Correspondent of the Scientific American

While the Diesel motor has of late been adopted quite extensively for the propulsion of vessels of small and medium size, its development into large units, such as required for big ships, has hitherto presented considerable difficulty.

It is realized to-day that the introduction of the Diesel motor for large marine engines would result almost in a revolution in the field of naval engineering, and many efforts are at the present time being spent on the design of an oil motor which shall work economically and with safety when built on such a large scale as required for great sea-going vessels.

Probably the most promising among the systems recently suggested is one which represents the outcome of many years systematic work in Prof. Junkers' experimental laboratory at Aix la Chappelle. Prof. Junkers in the first place, built a 200 horse-power engine, which was then used as a basis for the construction of a large 1,000 horse-power unit. This is at the present moment installed on the testing floor of the inventor's laboratory, and an idea of the size and appearance of the engine may be gathered from the half-tone illustration which accompanies this article.

The Hamburg-American line has recently intrusted a firm of Bremen with the construction of two 800 horse-power engines, to be installed on a vessel in course of construction. The same type of engine is also well adapted for stationary use, and a number of important German firms have acquired the rights of construction on a royalty basis. It appears, therefore, well worth while to give here a description of the working principles and design of the Junkers engine.

In the 1,000 horse-power horizontal type for stationary use the cylinder dimensions are: Diameter, 17.73 inches; stroke, 2 × 17.73 inches.

The engine comprises two pistons working in each of two cylinders located one behind the other. The outside pistons are made to act on the central crank bends, and the two inside pistons on the outside bends which are set at 180 degrees against the inside ones. The connection of the pistons with one another and the crosshead is effected by crosshead beams and rods. The engine is of the two-cycle type; the tandem arrangement results in a double effect, each stroke being a working stroke. While the pair of pistons in one cylinder performs an outward motion (working stroke), those of the other cylinder perform an inward motion (compression stroke).

At the moment of greatest approximation of the

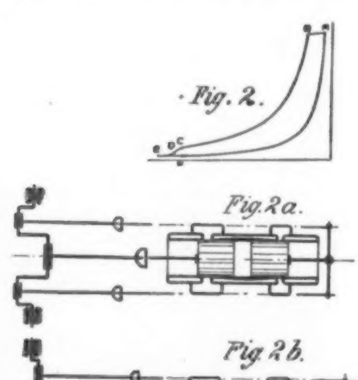


Fig. 2.—Indicator Diagram and Successive Steps in Cycle of Junkers Engine.

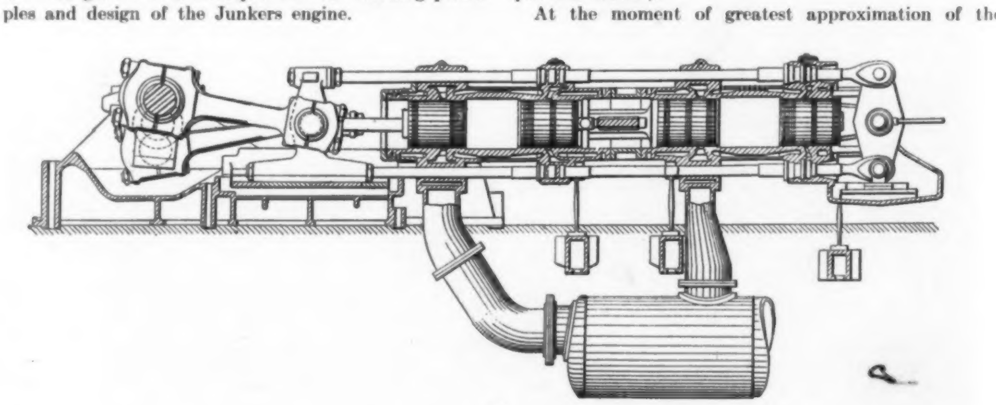


Fig. 3.—Sectional, Side and Plan Views of Junkers Engine.

two pistons in one cylinder, when the admission of fuel commences, the two pistons in the other cylinder are located at the maximum distance. In this latter position is effected the scavenging of any residual expanded gases, the scavenging air entering through the ring of ports at one extreme end of the scavenging compartment and pushing the combustion gases before it, discharging them at the other extreme end of the scavenging compartment. The steering of the rings of ports is effected automatically by the pistons themselves, so that all complicated valve gear, scavenging valves and stuffing boxes are avoided in the construction of the engine.

The mode of working of the Junkers engine is illustrated by the indicator diagram, Fig. 2, which, for the sake of simplicity, represents a single-cylinder arrangement. In Fig. 2*a*, which corresponds to the central dead point position, the compartment, after the compression stroke, has become filled with highly compressed and highly heated air, thus igniting the finely distributed fuel injected at that moment and during part of the outward stroke by means of compressed air, and burning it during the first part of the outward stroke (from *A* to *B*) approximately under constant pressure. As the outward stroke continues, this is followed by the expansion of the burnt gases (from *B* to *C*). At *C* the pistons have reached the position represented in Fig. 2*b*, in which the front piston *V* begins disengaging a ring of slots through which the exhaust gases are allowed to escape into the open (exhaust). On the way to the piston position represented in Fig. 2*c* (*CD* in the indicator diagram) an approximate compensation of pressures with the atmosphere has taken place. When arrived at this position, the rear piston *H* opens its ring of ports, allowing low-pressure fresh air to enter the cylinder, thus driving any residual exhaust gases left therein out through the exhaust port of the cylinder (scavenging). This continues beyond the outer dead point position of the pistons (Fig. 2*d*) as far as the piston position indicated in Fig. 2*e*, where the pistons, on their way back to the central dead point position, have locked both slots (*DEF* in the diagram). At *F* the cylinder compartment has become filled with fresh air and is locked against the atmosphere. The cylinder contents are then compressed as far as the central dead point position in Fig. 2*a*, the pistons continuing to approach (*FA* in the diagram). The compressed air is thereby heated to such a degreee that the fuel injected at point *A* or shortly before this, becomes ignited, immediately after which the same sequence of operations just described begins anew.

As regards the scavenging pumps and compressors used to produce the scavenging and intake air, these are arranged symmetrically to the cylinder axis and are driven from the crosshead beam of the central pair of pistons. This arrangement insures good balancing, remarkable ease of access, satisfactory distribution of the scavenging air, low mechanical losses and a simple, cheap and substantial construction. Each cylinder, if the diameter is at all considerable, is fitted with two intake valves and one compressed-air starting valve. The injection of the fuel has been so designed as to insure an efficient contact with the combustion air at the dead point and during part of the working stroke.

As regards the compensation of internal stresses and the balancing of moving parts it is claimed for the Junkers engine that it is considerably inferior to the standard form of Diesel motor. This is an important point even in the case of stationary engines, owing to the reaction upon the foundations, but becomes paramount for marine engines, where all pounding and vibration must be avoided so far as is at all possible.

In the case of the Junkers engine, the working cylinders are not made to transmit any forces and accordingly can expand freely. The transmission gear is made of wrought-iron. The foundation frame of the horizontal engine represented in Fig. 1 need be continued only as far as the first cylinder, while the cylinders themselves rest on simple I-shaped elastic supports. This makes the whole engine very economical and light as compared with other oil engines.

An interesting feature is that the cylinders are made without lids, which in the case of other oil motors are well known to be a source of continual danger and perpetual annoyance. The pistons on one side of the engine

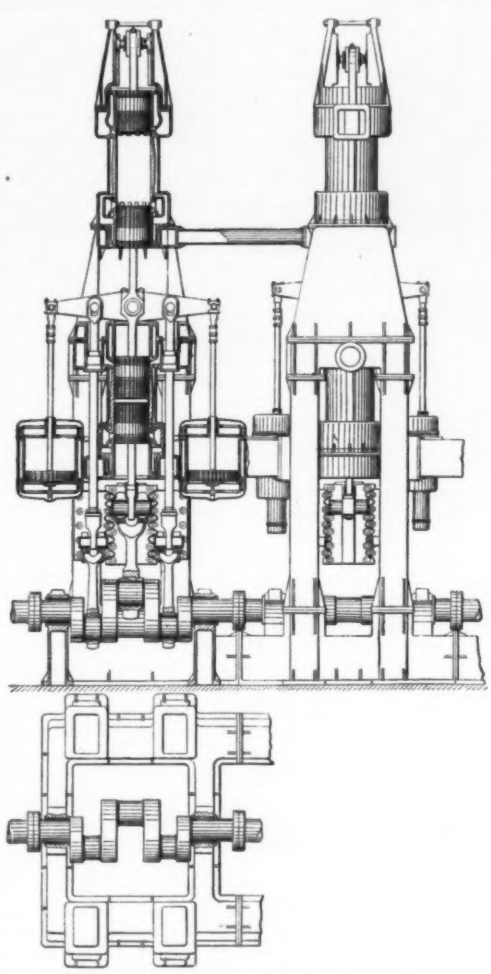


Fig. 4.—Vertical Form for Marine Service.

always communicate with the outside air and during each outward stroke are made to enter well cooled cylinder compartments which are not touched by the combustion gases. This at the same time warrants a satisfactory lubrication of the pistons, the more so as the lubricating oil is supplied at places which never come into contact with the hot inside compartment of the cylinder. The cooling of the cylinders and pistons is very effective.

The fact that the stroke is distributed over two pistons insures, with a relatively low speed of each piston, a high number of revolutions and a high total piston speed, which is a fundamental condition for the design of a light and cheap engine. The pistons are relatively short, thus adapting themselves better to the cylinders and being kept well fed with lubricating oil. The subdivision of the stroke also results in a long cylinder compartment of relatively small diameter, which is a necessary condition for a satisfactory combustion and scavenging action.

The great length of stroke of the Junkers engine exerts a most favorable influence, as borne out by theory and actual tests, the ratio of the surface to the contents of the combustion compartment being relatively small so that the amount of heat transmitted to the walls during the combustion, in the first part of the working diagram, is considerably lower than in any other Diesel engine. This also results in less cooling of the compressed air and accordingly in a greater rise of the compression curve toward the compression end, the desirable temperature of ignition being insured even with a very low number of revolutions. Actual tests on the 1,000 horse-power unit placed on the testing floor have shown that the engine, which under normal conditions works at about 200 revolutions per minute, will work even with small loads for a considerable length of time at about 30 to 40 revolutions per minute, the spontaneous ignition functioning perfectly. Owing to the good design of the combustion compartment, combustion can be made perfect even with considerable cylinder diameters.

The satisfactory working of a two-cycle engine is known to depend to a great extent on a good scavenging. Now, the design of the Junkers engine with its long working cylinders, minimal cylinder diameter and simple inside arrangement and with the reliable and accurate steering of the exhaust and scavenging openings, just complies with all the conditions required for proper scavenging.

The Junkers marine engine, as designed for use on a merchant vessel, is of the vertical tandem type, a substantial understructure warranting the necessary stability. While the arrangement of cylinders and gearings is in principle the same as in the horizontal engine described above, the design has been adapted to the vertical arrangement. This is essentially the type of engine intended for use in the merchantman of the Hamburg-American Line.

For warships, the horizontal tandem arrangement affords great advantages from a constructive, engineering and military point of view. Whenever special conditions make the use of vertical engines on board warships imperative, a single-cylinder arrangement has to be used, thus sacrificing the advantages of a tandem arrangement.

The use of a special process designed by Prof. Junkers for increasing the output of his engine is likely to assume special importance in connection with warship engines. This process consists in throttling the exhaust gases in the exhaust pipes, while supplying at the same time to the working cylinder a more considerable mass of air at a higher initial pressure, from scavenging pumps of larger dimensions. In consequence of the greater amount of compressed air, a greater quantity of fuel can thus be burnt.

As warships are called upon only occasionally and for short intervals to develop their maximum power, this possibility of considerably increasing the output is especially valuable. The simple and durable design of the combustion compartment of the Junkers engine lends itself thoroughly to such working with an increased initial pressure and a maximum output, so that there is every reason to suppose that this process for increasing the output of the Junkers engine may be adopted extensively in the navy, and perhaps also for the merchant marine.

Japanese Fans

The fan is one of few ancient inventions not introduced into Japan from a foreign country, having been designed by Empress Jingo (192-210 A. D.) who is said to have found the suggestion in a bat's wing. It was originally made of thirty-nine thin stays of kinoki wood, fastened with silk cord, the long ends of which furnish a decorative feature.

Fans soon became necessary accessories for court ladies, being used on all ceremonial occasions, to shield their faces while in the presence of gentlemen, as well as for the more usual purpose of fanning. In later periods paper fans were made after the same fashion, the number of stays being of course greatly reduced, and the art of painting was employed for the embellishment of both kinds.

The paper fans now generally used have thirteen bamboo stays. In selecting a fan, the Japanese man or woman notes very carefully whether the outside stays are the width of the fold in the paper, or merely form a narrow strip down its center; whether they are beveled or cut square at the ends; only a certain prescribed size may be used by each; another specific size is made for children—for no one must be without this important article, or fail to learn the many meanings attached to it in one way or another. A man's fan is 10½ to 11 inches in length; a woman's about 7¾ inches, and a child's not more than 6 inches, sometimes even shorter. All may be in colors and with decoration, there being favorite designs, chief among which is a large sun upon a plain ground, the colors being red and gold, used interchangeably. Plain white fans are, however, preferred by many, who wish to have some friend write a poem or sketch a flower or the like thereon.

A particular kind of folding fan is used by priests; its outer stays are curved outward, so as to cause the folds to remain extended, like a half-open accordion. Folding fans made of silk gauze and exquisitely embroidered or daintily painted, and with carved sandal wood or ivory stays, are exported in large numbers but are not used by Japanese. Army officers use gourd-shaped fans of black lacquered wood with gold ornament (in rare cases even jeweled) in giving orders. Round fans are used largely by Japanese tradesmen for advertising purposes, and hundreds of thousands are exported to foreign countries for the same purpose. Silk fans are also largely exported and sold for their decorative effect. Paper fans coated with the juice of green persimmons are used by kitchen maids to fan their charcoal fires.

The manufacture of fans forms quite an industry in Tokio, Kioto, and other cities. Skilled workmen make a specialty of splitting the bamboo for the frames of the round fans and artists of no mean talent are employed in decorating the fans. In the center of the industry in Tokio, there are six large wholesale firms, producing two million fans annually.—*Japan Magazine.*

Electric Enterprises in Japan.—According to official investigations, the electric companies registered at the end of September, 1911, number ten to sixteen in all, the electric power generated totaling 472,205 kilowatts, and the total capitalization reaching 355,179,731 yen (about $177,589,860). When classified according to the nature of the electric business the results are as follows:

	No.	Authorized capital. *Yen.*	Paid up capital. *Yen.*
Supply of electricity.....	186	199,348,055	127,998,960
Electric street cars......	15	25,110,000	14,927,500
Electric street cars and supply of current......	25	130,721,678	993,532,239
Private use	697	....	....
Government use	93	....	....

The companies which have obtained charters but have not yet commenced business number 168, their electric power aggregating 381,232 kilowatts.—*Japan Weekly Mail.*

Electrical Disturbances and the Nature of Electrical Energy*

By Charles P. Steinmetz

To all of us who are interested in the use of electric energy the nature and characteristics of electric energy are of importance; as on their understanding depends our success in the economic use of this energy, and our ability of guarding against the difficulties, troubles and dangers which it may threaten when out of control.

Electric energy is industrially used as direct current and as alternating current, that is, as steady flow and as wave motion, usually of 25 or 60 cycles. Electric disturbances are of various character, and, where they are periodic or wave motions, are often of very high frequencies.

It can not well be doubted that electric disturbances in our systems are increasing in number. The reason therefor is found in the increasing size and energy of modern electric systems. Just as in a pail of water even a gale will not cause an appreciable disturbance, or, as a small pond is usually quiet while the ocean is never at rest, but continually traversed by undulations from small ripples to big waves, so in a small isolated plant high voltage disturbances are practically unknown; are rare in smaller central stations; while in the huge modern systems waves continuously traverse the circuits, from minute high frequency ripples of negligible energy to occasional high power surges of destructive energy.

The nature and form of disturbances met in electric systems are as variegated as those of any other form of energy. Single electric waves or impulses may appear as magnetic discharges, analogous to the snap of a whip in acoustics. Oscillations appear as waves which start suddenly and gradually die out, like the waves produced by throwing a stone in water; such are the disturbances caused by switching, synchronizing, etc. Then there are traveling waves, analogous to the ocean waves, of various size and wave length; such for instance as the disturbances caused by arcing grounds, by lightning, etc. Standing waves or stationary oscillations, like those of a tuning fork or violin string, may appear; and occasionally also, the most dangerous of all disturbances, cumulative oscillations, like the resonance of a tuning fork, namely, oscillations which gradually build up, increase in intensity until they finally limit themselves and become stationary, or die down again, or increase until something happens. Such for instance are the hunting of synchronous machines, certain internal transformer oscillations, etc.

Disturbances may affect the system by their quantity, or by their intensity. Electric power can be resolved into the product of two terms, quantity (or current) and intensity (or voltage), just as most other forms of energy are resolved into the product of two terms. Hydraulic energy is quantity of water times head or pressure; heat energy is entropy times temperature, etc. Instances of current disturbances are the momentary short circuit currents of alternators, the very high frequency currents of arcing grounds, etc. Voltage disturbances appear wherever an electric wave breaks at a barrier in a circuit, as at a reactance, or in the end turns of a transformer.

A wave in the water, as a big ocean wave, may cause damage by its bulk, by overturning a structure. So a current wave may cause damage by its volume: the momentary short circuit current of an alternator may tear the windings to pieces, twist off the engine shaft, etc. Again, waves in the water too small of themselves to do any harm, may still do harm by the continuous pounding—by undermining and washing away the shore. In such manner a continuous oscillation—a continuous surge—may destroy. Each individual electric impulse would not have sufficient energy to do damage, but when they follow each other successively, in thousands and millions, as coming from an arcing ground, then finally they cause destruction. Again, the damage may be done by the pressure or voltage. Just like an ocean wave, not high enough in itself to overtop the shore, when stopped at the beach, when breaking in the surf, throws the water up to heights that are much greater than the height of the wave, so in the same manner a voltage impulse in an electric distribution system, when it breaks at the entrance to another circuit, at a reactance, or the end connections of the transformer or generator, or the series coil of a potential regulator, may pile up high voltage and rise to values far beyond those which the wave has in its free path in the cable or the line; and there, at the point where it breaks, where the wave is abruptly stopped by reactance, the voltage may rise to destructive values.

Disturbances may enter the electric system from the outside, as by lightning; or they may originate in the system, as by switching, synchronizing, etc.; or again, they may originate in the circuit by outside interference, as by an arcing ground, a spark discharge to an isolated conductor, etc.

A characteristic of most of these disturbances (which usually are comprised by the name of transients) is that they easily pass from circuit to circuit across space by magnetic or static induction, but frequently do not travel along the circuit for any considerable distance. The cause of this is found in their nature, particularly the frequency.

When an electric current passes through a circuit, there is in the space surrounding the conductor which carries the current an electric field; lines of magnetic force surround the conductor, and lines of electrostatic or dielectric force radiate from the conductor. In a direct current circuit, if the current is continuous, the field is constant; there is a condition of stress in the space surrounding the conductor, which represents stored energy, magnetic energy and dielectric energy, just as a compressed spring or a moving mass represents stored energy. In an alternating current circuit, the electric field also alternates; that is, with every half wave of current and of voltage, the magnetic and the dielectric field start at the conductor, and run out from the conductor into space with the velocity of light, or 188,000 miles per second. Where this alternating field of the conductor, this electric wave, impinges on another conductor, a voltage and a current are induced therein. The induction is proportional to the intensity of the field (the current and voltage in the conductor which produce the field) and to the frequency. Thus, where the frequency is extremely high, intense induction occurs; that is, considerable energy is transferred from the conductor which produces the electric wave (the primary or sending conductor) to any conductor on which the wave impinges (the secondary or receiving conductor). The result is, that a large part of the energy of the primary conductor passes inductively across space into secondary conductors, and the energy decreases rapidly along the primary conductor. In other words, such a high frequency current does not pass for long distances along a conductor, but rapidly transfers its energy by induction to adjacent conductors. This higher induction, resulting from the higher frequency, is the explanation of the apparent difference in the propagation of high frequency disturbances from the propagation of the low frequency power of our alternating current systems: the higher the frequency, the more preponderant become the inductive effects, which transfer energy from circuit to circuit across space, and therefore the more rapidly the energy decreases and the current dies out along the circuit, that is, the more local is the phenomenon.

The flow of electric power thus comprises phenomena inside of the conductor, viz., the dissipation of electric energy by the resistance of the conductor through its conversion into heat and phenomena in the space outside of the conductor—the electric field—which, in a continuous current circuit, is a condition of steady magnetic and dielectric stress, and in an alternating current circuit is alternating, that is, an electric wave issuing from the conductor and traveling through space with the velocity of light. In electric power transmission and distribution, the phenomena inside of the conductor are of main importance, and the electric field of the conductor is usually observed only incidentally, when it gives trouble by induction in telephone circuits, or when it reaches such high intensities as to puncture insulation, cause mechanical motion, etc. Inversely, in the use of electric power for wireless telegraphy and telephony, it is only the electric field of the conductor, the electric wave, which is of importance in transmitting the message; the phenomena in the conductor, the current in the sending antenna, are not used.

The electric waves of commercial alternating current circuits usually have the frequencies of 25 and 60 cycles. With a velocity of propagation of 188,000 miles per second, 25 waves per second give a wave length of $\frac{188,000}{25} = 7,500$ miles. The distance to which the field of a transmission line extends is, therefore, only an insignificant part of the wave length, and the phase difference within the field of the transmission line thus is inappreciable. With the alternating fields of transmission lines, the effect of the velocity of propagation of the field is therefore negligible and is always neglected. Not so with the alternating field of a wireless telegraph station. Using frequencies from one hundred thousand to a million cycles, the wave length is from $\frac{188,000}{100,000} = 1.8$ miles to $\frac{188,000}{1,000,000} = 0.188$ miles, or about 1,000 feet. With a wave length of from 1,000 feet to 2 miles, the electric wave extends over hundreds of cycles within the operative radius of a wireless telegraph station, which may be hundreds or even thousands of miles. It is appreciable also in long distance telephone lines. The average frequency of the sound waves—500 cycles—gives a wave length of 376 miles, and a 1,000-mile telephone line thus comprises over 2½ waves. That is, at the moment when one-half cycle of telephone current arrives in Chicago from New York, five succeeding half waves have already left the New York terminal and are on the way.

Abnormal electric waves in industrial electric power circuits vary from a few cycles per second (in the stationary oscillations of compound electric circuits) up to thousands, hundreds of thousands and millions of cycles per second. At frequencies of many thousand cycles per second, the ordinary measuring instruments, the oscillograph, etc., fail to record the wave; but such very high frequency waves can still be observed and measured through their inductive effects by bringing a conductor near them: the electric wave, impinging on this exploring conductor ("resonator" or "receiving antenna") then induces a current in it, and this is observed by a sufficiently delicate apparatus. In this manner, the telephone disturbances caused by alternating electric railway circuits have been studied by exploring antennae. A very intense wave, at short distance from its origin, may be observed by the spark across a small gap in the exploring antenna. Inversely, at hundreds of miles distance from the wireless sending station, the extremely weak wave is still observed in the receiving antenna by a change of the surface tension of a platinum hair wire dipped into an electrolyte, the change in resistance of which operates a relay. By the exploring antenna, electric waves have been studied and observed up to frequencies of hundreds of millions of cycles per second—so-called "Hertzian waves,"—as they occur in industrial circuits between the end cylinders of high voltage multi-gap lightning arresters. There, they are the cause of the high sensitiveness of the arrester for high frequency disturbances.

We have to realize though, that light and radiant heat, the Hertzian waves, the waves of the wireless telegraphy station, the alternating fields of our transmission and distribution circuits, are one and the same phenomenon—electric waves traveling through space with the same velocity (188,000 miles per second) and exhibiting the same characteristics, but differing merely by their frequencies. This does not mean that electricity and light are the same, but that light is an extremely high frequency electric wave, an extremely rapid alternating electric field, while the electric field of the direct current is a steady stress in space.

From our knowledge of the identity of the alternating electric field and the wave of light radiation, we can derive a number of interesting relations between electric phenomena and the phenomena of light. To mention only one: the secondary current is repelled by the alternating magnetic field which induces it, that is, by the electric wave impinging upon it. This fact is made use of in the constant current transformer for constant current regulation. Applying the same phenomenon to the extremely high frequency light waves, means that the body which intercepts the light wave is repelled by the wave—the radiation pressure. Thus at extremely high frequencies the radiation pressure is the analogous phenomenon to the repulsion between primary and secondary circuits in our industrial circuits.

So far we have made no hypothesis, but merely recorded the facts: we can measure the waves and their frequencies, their velocity of propagation and other characteristics, and show their identity. We may now speculate on the nature of the electric wave, on the mechanism of its propagation, etc.; but must then realize, that as soon as we leave the facts and indulge in speculation, we submit to uncertainty, which every hypothesis has, no matter how well founded.

The velocity of propagation of the electric wave is incredible, but it is a finite velocity, and after the electric wave has left the sending antenna, a finite time elapses before it is observed by the receiving antenna.

* An address to the Association of Edison Illuminating Companies at their convention in Spring Lake Beach, N. J. Published in the *General Electric Review* and reprinted in the Scientific American Supplement by special permission of the Association.

The energy sent out by the oscillator, the electric circuit, the sending antenna, is thus received by the receiving antenna at a later time. The finite speed of propagation of the electric wave implies that the energy during its motion from the starting point to the point observed must reside for some time in intervening space. This means that there must be something in the space which carries the energy; a carrier of the energy of radiation, of light. That carrier we explain by the hypothesis of the luminiferous ether. We assume that the ether permeates all space, is of extreme tenuity and fineness, and is the carrier of the electric wave. The question arises: Is the ether a mere hypothesis, or is it real? Is it a form of matter or not? We may speculate on that, but may come to one conclusion or to the opposite conclusion, according to our definition of what matter is. After all, it is really not a question of speculation, but a question of definition—of what you define as matter.

We always speak of the phenomena of nature within the conception of energy and of matter. Energy we can perceive by our senses. All we know of nature, all that our senses give us as information, is the effect of energy—energy which reaches our body through the eyes, through the ear, through the sense of touch; and if I were to make a definition of energy it would be "that thing which reacts on, and is perceived by, or can be perceived by, our senses."* This is probably the most consistent definition of energy.

Now, what is matter? We cannot see or get any knowledge of matter. If we see a thing, we do not see the matter, but we see the radiating energy from it which comes to us. We feel the mechanical energy of its momentum, but the matter we cannot perceive. All the conception of matter is as the carrier of energy; but if you define matter as the carrier of energy, then the ether which carries radiating energy—carries the energy of the electric wave—is just as much matter as the bullet which carries the mechanical energy that was supplied to it in the gun.

The question then arises: What are the properties of this ether, which is the carrier of the electric wave? The velocity of propagation of a wave in a medium depends on its density and elasticity. The velocity of propagation of the electric wave through the ether is nearly 200,000 miles per second, while the velocity of sound waves through the air is about 1,000 feet per second, or the electric wave moves a million times faster than the sound wave. This means that the ether must be of a density inconceivably lower than that of air, though we speak of the air as being of low density, and realize this when trying to navigate it. Furthermore, through the ether all cosmic motion takes place: our earth rushes through it at high velocity, and still there is no appreciable friction. That means that the density of the ether must be so enormously low that even at very high velocity the frictional resistance is inappreciable.

We might then consider the ether as a gas of inconceivably low density.

However, the light wave or electric wave is a transverse vibration; that is, the oscillating ether particles oscillate at right angles to the direction in which the ray of light travels, and therefore in their oscillation come neither nearer nor recede further from the ether particles in front or behind in the direction of the beam of radiation. The oscillation cannot be transferred from ether particle to ether particle in the direction of the beam, by approach or recession of the ether particles, and the transfer of oscillation in the direction of the beam thus can occur only by some thing, some force, which holds the ether particles together, so that a side motion of one causes a corresponding side motion of the particle ahead, without approach. That is, the ether particles can not be free as in a gas, but must be held together with some rigidity. In other words, the existence of transverse vibrations precludes that the ether is a gas, and requires it to be a rigid body, a solid: transverse oscillations can occur only in solids, but are inconceivable in fluids. From the nature of the wave motion of light, we thus would have to conclude that the ether, through which the earth and all bodies rush with high velocity, and without appreciable friction, is a solid. This is physically impossible, and here we find a very common physiological phenomenon: if we attempt to carry any speculation or theory to its final and ultimate conclusion, we reach contradictions. This probably is not the result of the nature of the phenomena, but is in the nature of our minds, which are finite and limited, and therefore fail when attempting to reason into the infinite.

A speculative hypothesis on the nature of electrical phenomena has in the last years been developed in the *ionic theory*. Its starting point is the study of the phenomena of conduction, more particularly the conduction of gases and vapors. In this, we must not merely consider typical cases, but cover the entire field of conductors. On first sight, it appears easy to divide all electric conductors in two classes: metallic conductors or conductors of the first class, in which the resistance slightly increases with increase of temperature, and electrolytic conductors or conductors of the second class, in which the resistance slightly decreases with the temperature. Further investigation shows, however, that there are numerous conductors which do not belong in either class, such as gases, vapors, etc., and that there are all transition stages between the different conductors represented, so that we can not speak of classes any more, but merely of types. Thus there are solid conductors, such as metallic oxides (for instance magnetite) and elements and their alloys, as silicon, etc., which, with a change of temperature, gradually change from metallic conductors of positive temperature co-efficient to conductors of metallic character, but with negative temperature co-efficient; and which at still other temperatures have such high negative temperature co-efficients that the voltage decreases with increase of current, thereby having the same characteristics as are conductors; while at still higher temperatures they become electrolytic conductors. Such "pyroelectrolytic" conductors, to which the Nernst lamp glower belongs, are interesting because of the change of type of their conduction. Equally, if not more interesting, are gases and vapors as conductors, such as the arc, the Geissler tube, the static spark, etc. There seem to exist two classes of gas or vapor conduction: to the one belong the arcs, while to the other belong the Geissler tube and the electrostatic spark. Again, on first sight, it appears difficult to realize that the silent faintly luminous Geissler tube discharge, and the brilliant and noisy electrostatic spark, are one and the same phenomenon. However, the one changes gradually and without dividing line into the other by a change of gas pressure, and the difference in the gas pressure. Furthermore, the usual noise and brilliancy of the static spark at atmospheric pressure is largely the result of the circuit condition under which it is produced: the passage of the spark closes the circuit and thereby starts a momentary more or less unlimited flow of electric energy. If, however, this short circuiting effect of the spark is eliminated, as for instance by interposing between the spark terminals a glass plate which is not punctured, the electrostatic sparks appear as thin colored moderately luminous discharges which pass with moderate noise, the apparent difference from the Geissler discharge being then far less. With decreasing gas pressure, the electrostatic spark becomes less noisy, less brilliant, longer and thicker, and finally changes to the noiseless steady stream of the Geissler discharge, which traverses the space between positive and negative terminal with a glow, its color depending on the nature of the gas: for example, the glow is pink with air, orange-yellow with nitrogen, green with mercury vapor, etc. Going still to higher and higher vacua, the conductor which passes the current between the positive and negative terminal of the vacuum tube finally changes again and becomes a green discharge, which issues from the negative terminal in straight lines, like a beam of light, irrespective of where the positive terminal is located. It may not reach or come anywhere near the positive terminal, and if the positive terminal is located back of the negative terminal, the cathode ray, issuing from the latter, will really proceed away from the positive terminal.

Now, this form of electric conduction (and to a considerable extent the conduction of the Geissler tube at lower vacuum) looks very much like electric convection: it looks as if the electric energy were carried across the terminals by luminous material particles, which are shot off, in straight lines, from the negative terminal with great energy, producing luminosity where they strike; and after losing their luminosity have to find their way to the positive terminal. The transfer of electric energy by the cathode ray would then have the same relation to the transfer of electric energy by a copper wire as the transfer of kerosene by a series of tank cars has to the transfer of kerosene by a pipe line.

Assuming then the hypothesis that the cathode ray is the transfer of electric energy by convection by material particles, we will see what conclusions we can derive therefrom.

A material particle containing electric energy is acted upon by an electrostatic field, in a direction depending on the polarity of the electric energy, whether positive or negative against surrounding space. The cathode ray, if consisting of material particles, thus would be deflected by an electrostatic field by an amount depending on the intensity of the field and on the energy, mass and velocity of the material particles. This is the case: the cathode ray is deflected, and measurements of the deflection of this ray by the electrostatic field thus give us a relation between electric energy, mass and velocity of the cathode ray particles. Moving electric energy, whether flowing through a metal conductor or carried by a moving particle, is acted upon by a magnetic field. The cathode ray thus should be deflected by a magnetic field by an amount depending on the electric energy, mass and velocity of the moving cathode particles. This is the case. From these two relations, given by the deflection of the cathode ray by the electrostatic and by the magnetic field, respectively, we can calculate the mass and the velocity of the moving cathode ray particles. If the masses of the cathode ray particles, calculated by this assumption, were found to be of the same magnitude as masses of other particles, calculated by other means, such as the chemical atoms or molecules, if their velocities were comparable with other known velocities, this would be a strong confirmation of the hypothesis of electric convection by the cathode ray, that is, of the ionic theory. However, this is not the case, and the experiment therefore neither confirms nor contradicts the ionic theory. The calculation shows that, if the conduction of the vacuum tube is by convection of electric energy by moving particles, these particles, called electrons, must be very much smaller than the chemical atoms, or of a magnitude of one-thousandth the size of the smallest chemical atom, the hydrogen atom. Their velocity of motion must be inconceivably high—comparable with, though smaller than the velocity of light. They carry electric energy at a negative potential against surrounding space, that is, the electron may be considered as the negative terminator of a line of dielectric force, while the positive end of this line of dielectric force terminates at the positive terminal of the vacuum tube, or at a positive electron, where such exists.

The question then arises: What is the electron? By the derivation of its hypothetical existence, it is a form of matter, since its mass has been calculated by the action of forces on its mechanical momentum. It thus would be a new form of matter, a new chemical atom, a thousand times smaller than the hydrogen atom. It has been called "an atom of electricity." As "electricity" is a vague term without physical meaning, which has loosely been used for "electric quantity" (and even "electric quantity" is a mere mathematical fiction, a component factor of electrical energy) no objection exists to giving the name "electricity" to this new hypothetical form of matter, represented by the electron. It naturally does not explain anything: The electron certainly is not electric quantity, nor is it electric energy, but it may be defined as that form of matter which is the carrier of electric energy. Then, however, the electron in its definition comes rather close to the hypothetical ether atom, which is the carrier of radiant energy, that is, the carrier of the energy of the electric wave in space.

The electron, however, can not be considered as electric energy, nor as representing or carrying a definite amount of electric energy, even when associated with a definite quantity of electricity, no more than the iron atom of a magnetic circuit can be considered as magnetic energy, or as carrier of a definite amount of magnetic energy. Energy comprises the product of quantity and intensity, and the electric energy carried by the electron is its electric quantity times the intensity of its electric field, that is, the potential gradient along the line of dielectric force, which starts at the electron, up to a reference point on this line of dielectric force—the potential of the positive terminal, of surrounding space, of the universe, or anything else. This disposes of the mistaken conception, occasionally expressed, that the electron represents a definite amount of electric energy, and leaves the amount of energy of the electron indefinite, that is, depending on an arbitrarily chosen reference potential, just as it is with any other form of energy: the amount of energy of any carrier of energy, such as a moving body, is always relative, depending on a reference point.

Obviously, then, electric energy can not be measured by the number of electrons, and has no direct relation to it, but depends on the electric intensity, or potential difference.

In the last years, the ionic theory has been greatly strengthened by the discovery and investigation of phenomena similar to those of the cathode ray, though more general in nature, in the radiation of so-called "radio-active substances." A number of chemical elements, such as radium, thorium, uranium, etc., continuously send out rays of various kinds. Some of these, the β rays, are identical with the cathode rays of the vacuum tube, or, in other words, are deflected in the same manner by electrostatic and magnetic fields, and are therefore considered as electrons—terminators of the negative end of a line of dielectric force, of a mass about a thousandth that of the hydrogen atom, shot off by the radio-active substance with velocities approaching that of light. Other rays, the α rays, are deflected in an opposite direction by electrostatic and magnetic fields, and thus must be considered as carriers of electric energy of positive potential: positive electrons. Their mass, as calculated in the manner above described, is that of the helium atom (4 times the mass of the hydrogen atom), and they are therefore generally considered as helium atoms carrying electric energy of positive potential. They are shot off with velocities very much lower than the velocities of the negative electron, though still incon-

* Compare W. Ostwald: "Energy is that which can be distinguished in time and space."—The Editor of the Scientific American Supplement.

ceivably high. When carrying electric energy, they contain the same quantity of electricity at positive potential that the negative electrons carry at negative potential, and if the latter are considered as terminators of the negative end of a line of dielectric force, the helium atoms as positive electrons are terminators of the positive end of a line of dielectric force.

A third class of rays, issuing from radio-active substances, are the γ rays. They have the same characteristics as the other rays, except that they are not deflected by electrostatic or magnetic fields. They are identical in their properties with the X-rays, discussed above as electric waves at the extreme end of high frequencies, and are usually considered as X-rays.

Here we come to one of those conclusions which do not appear rational: the α, β and γ rays are very similar in their nature, differing only by the direction and amount of their deflection, and it therefore does not appear reasonable to assume that the γ rays are ether waves, while the α and β rays are projectiles thrown off by the radio-active mass. The attempt of avoiding this dilemma by assuming the γ rays to be projectiles, which carry equal positive and negative electric quantity, and therefore are not deflected, appears forced and merely transfers the difficulty into the relation between X-rays and ultra-violet light. The latter is generally conceded—and corroborated by the phenomena of interference, etc.—to be ether waves. At the extreme ultra-violet, however, the properties begin to shade into those of the X-rays, and it again appears unreasonable to assume such an essential difference between ultra-violet and X-rays, as that the ones are ether waves, the others projectiles.

In many instances, when we follow the reasoning of the ionic theory to its conclusion, we meet contradictions. For instance, the calculation of the mass of the electron shows that at very high velocities the mass is not constant, but increases with increasing velocity, becoming infinity; and therefore the kinetic energy of the electron becomes infinite, if its velocity equals the velocity of light. This is impossible, as it contradicts the law of conservation of energy: if we consider two electrons, moving in opposite directions at half the velocity of light, their kinetic energy against surrounding space would be finite. Their relative motion against each other, however, is at the velocity of light, and their kinetic energy against each other would be infinite. Since, however, they were set in motion by finite energy, their relative energy can not be infinite. To overcome this difficulty, a fictitious or apparent mass—the "electromagnetic mass"—has been attributed to the electrons, which is not the mass of mechanics. However, the calculation of mass and velocity of the electrons is based on the kinetic energy of the electron, that is, on its mechanical mass, and not a new kind of mass, which is not a mass in the mechanical sense.

These and other numerous contradictions to which the conception of the ionic theory leads, obviously do not mean that the ionic theory is fundamentally wrong in principle: we have also seen that the wave theory of radiation, in the properties of the luminiferous ether, lead to attributes that are contradictory and thereby impossible. We find the same thing in all theories—the chemical, the thermodynamic, etc. It simply means that our present formulation of the ionic theory, of the electromagnetic wave theory, and of all other theories are very far from final correctness, but are at best only very crude conceptions of the nature of things, which will have to be modified again and again with our increasing knowledge before we can expect to reach a moderately rational conception of nature's laws and phenomena, if we ever arrive there.

The Magnetic Field of Cathode Rays

One characteristic property of the cathode rays is the fact that they are deflected by the magnet. These rays, as is well known, consist of electrons projected into a vacuum tube (Fig. 1) from an electrode charged to a high potential, and behave exactly like an ordinary conductor carrying a current. The question naturally arises whether such a cathode ray produces a magnetic field of its own, corresponding in character to that which an equivalent conductor would create, as indicated in Fig. 2. Although there was every probability that this should be the case, numerous experiments devised to furnish positive proof of the fact failed to

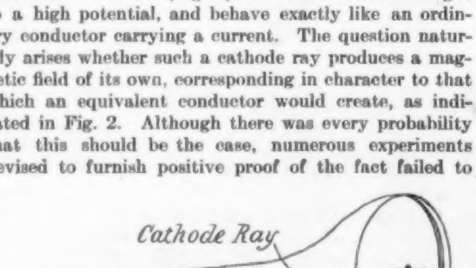


Fig. 1.—The Magnet Deflects the Cathode Ray in the Direction of the Arrow Seen on the Fluorescent Screen.

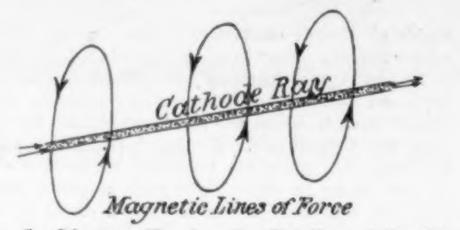


Fig. 2.—Diagram Showing the Relation of the Magnetic Lines of Force to the Cathode Ray.

give the desired result. On this account special interest is attached to a recently published work of Joffe, noted in *Prometheus*, which furnishes the required evidence. This observer made the cathode ray part of a closed circuit. The current represented by the cathode ray could be measured by means of a galvanometer G (Fig. 3). It was then found that within the close limits of

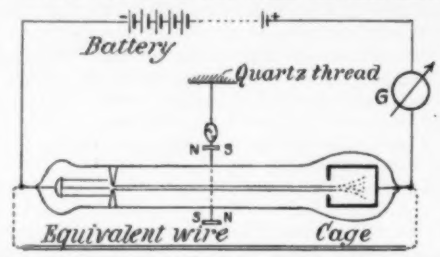
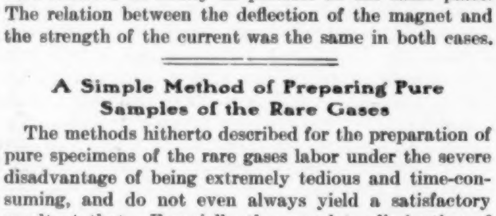


Fig. 3.—Diagram of Toffe's Experimental Arrangement.

experimental error the same deflection was caused in a small pair of magnets suspended from a quartz thread (see Fig. 3) whether the current was transmitted in the form of a cathode ray or through an equivalent copper wire inserted as nearly as possible at the same place. The relation between the deflection of the magnet and the strength of the current was the same in both cases.

A Simple Method of Preparing Pure Samples of the Rare Gases

The methods hitherto described for the preparation of pure specimens of the rare gases labor under the severe disadvantage of being extremely tedious and time-consuming, and do not even always yield a satisfactory result at that. Especially the complete elimination of hydrogen and carbon-monoxide is attended with the greatest difficulties. A process described by Gehlhoff in the proceedings of the German Physical Society, 1911, and presented in brief extract in *Prometheus*, from which our illustration is taken, therefore deserves special notice. The principle of the process depends on the fact



Use of Potassium in the Preparation of the Rare Gases

that vapors of the alkali metals will, under the influence of the silent electric discharge, so completely absorb hydrogen, carbon-monoxide, oxygen, and nitrogen, that these gases can no longer be detected by the spectroscope. Gehlhoff uses a vapor of the comparatively cheap metal potassium, which acts very energetically at 200 degrees. The apparatus adapted for this purpose is shown in our illustration. The purifying flask is connected through tap I to the air-pump, a charge of potassium being introduced through a separate opening. The flask is then filled with the impure rare gas. Between the potassium, which serves as cathode, and an anode fused in through the wall of the flask, a silent discharge is established. After but a few minutes the gas is pure, and a Geissler tube fed through tap II shows to the observer through the spectroscope the pure spectrum of the gas under treatment.

Limiting Value of the Shortest Possible Sound Waves

It is well known to every student in elementary physics that sound is propagated in the form of waves of alternate compression and dilatation. In air its velocity is about 1,100 feet per second. The frequency of the waves varies according to the nature of the source, and is recognized by the ear, the sound heard being the "higher" in pitch the greater the frequency, or, what amounts to the same thing, the smaller the wave-length. Thus, for example, if on striking a bell (Fig. 2), 220 vibrations per second are produced, the length l of one wave, or in other words, the distance, measured in the direction of propagation, between two consecutive points in the air at which conditions are precisely similar will be given by

$$\frac{1100}{220} = 5 \text{ feet.}$$

A simple means for determining the length of sound waves is furnished by the so-called Kundt's dust tube. This is represented in Fig. 2. A glass rod firmly clamped at its middle in a suitable support, as shown on the

Fig. 1.—Diagram of Sound Wave.

right-hand side of the drawing, is set vibrating by rubbing it with a piece of wet leather held in the hand. The farther end of the rod, which carries a cardboard disk, extends into the dust tube, the air in which is set vibrating. By adjusting a piston inserted at the opposite end of the tube, the length of the vibrating air column can be regulated until it is an exact multiple of the wave length of the sound produced by the rod. The instant when this occurs is easily recognized if the tube has been sprinkled with some fine powder, such as lycopodium. For as soon as the right adjustment is reached this powder arranges itself in little clusters or heaps at regular intervals, corresponding to the distance between the

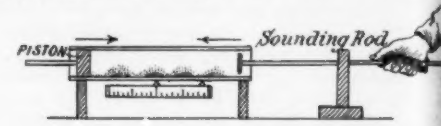


Fig. 2.—Kundt's Dust Tube.

crests of the sound waves. This distance can then be measured by means of a suitable scale, as indicated in the drawing.

The Russian physicist Lebedew has recently established the fact that, while sound waves of a medium wave-length suffer very little absorption in the course of their propagation, this absorption becomes very considerable in the case of short waves. The following table gives the distance D in centimeters from the sounding source at which a wave of wave length l is reduced to one-hundredth of its original intensity:

Wave-length l Millimeters.	Distance D from the Source, Centimeters.
0.8	40
0.4	10
0.2	2.5
0.1	4.6

From this table it will be seen that 1/10 of a millimeter represents about the limit of the length of sound waves accessible to observation.—*Prometheus.*

Artificial Production of Well Water

The only water suited for city supply systems is mineralized well water, containing nitrogen only in the highest degree of oxidation. As, however, this underground water mostly fails to suffice for actual requirements, attempts have been made to mix it with river water, imparting to the latter by natural filtration all the properties of underground water.

At a recent meeting of the Geological Association, Frankfort-on-the-Main, Baurat Scheelhaase gave an interesting account of his method for converting river water into well-water, which has already been carried out into practice with satisfactory results. The water of the river Main, having passed through artificial filters, is allowed to ooze thorugh the soil. After having reached a certain depth in about three weeks, this water filters through a distance of 500 meters as far as the Oberforsthaus pumping station. Even at 425 feet distance from its entrance into the soil, the Main water is found to be equivalent to the natural underground water. It takes three years to arrive from the point of entrance to the pumping station. The output of the plant is 14, cubic feet of water per day.

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